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UNITED STATES AIR FORCE

PROJECT FUNCHAS

INTELLIGENCE AND RECONNAISSANCE

REPORT

VOL II

JANUARY 1964

SECRET

SUBF NO-20

[illegible]

[illegible] the Report of the Intelligence and Reconnaissance Panel, Chairman of the Advisory on Project FORECAST. [illegible] contains the findings and recommendations of the Panel as approved by the Chairman, but does not represent the opinions of the Project FORECAST Directors. The findings of this Panel are reflected in the Panel Report. Specific data and figures in this report concerning yields, weapons, or inventory are to be treated as intelligence only and not as [illegible] planning information.

O. J. Ahlquist
Major General, USAF
Chairman, Intelligence and
Reconnaissance Panel
Project FORECAST

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[illegible]

Volume I	Section [illegible]	[illegible]	[illegible]
Volume II	Section [illegible]	[illegible]	[illegible]
Volume III	Section [illegible]	[illegible]	[illegible]
	Appendix A	[illegible]	[illegible]
	Appendix B	[illegible]	
	Appendix C	[illegible]	
	Appendix D	[illegible]	

Section II of the overall [illegible] Report is presented in this document. This material [illegible] in conjunction with the [illegible] systems analyses [illegible] by the panel.

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e. Electronic Signal Image Recording
f. Special Photo-Processing Techniques
g. Image-Data Processing Hardware and Equipment

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b. High-Acuity Reproduction
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[illegible]

[illegible]

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1.0 INTRODUCTION

1.1 Purpose and Scope

The objectives of this report are:

1) To assess the [illegible] in the [illegible] support of [illegible] and [illegible] and [illegible]

2) To predict the [illegible] of [illegible] [illegible] forecast advances during the forecast time period.

3) To determine current [illegible] [illegible]

4) To recommend changes to [illegible] and [illegible] development efforts.

5) To recommend new [illegible] development [illegible] [illegible] intelligence and [illegible]

Unmanned intelligence and [illegible] [illegible] [illegible] [illegible] [illegible] and information on enemy [illegible] [illegible] [illegible] includes photography and electronic [illegible] [illegible] and unusual sensors.

2.1 Approach

For purposes of this [illegible] [illegible] [illegible] [illegible] [illegible] technology, [illegible] [illegible] [illegible] photography, electronics, [illegible] [illegible] [illegible] passive electromagnetic (EM) sensors, [illegible] [illegible] [illegible] data extracting, information storage, [illegible] [illegible] [illegible] integration, unusual sensors and resources. [illegible] [illegible] [illegible] usual sensors and resources each of these [illegible] [illegible] respect to state-of-the-art, [illegible] [illegible] and advanced development. Considerations of [illegible] [illegible] to a partial listing of [illegible] [illegible] together with recommendations for [illegible] [illegible] tion efforts. Future feasibility and [illegible] [illegible] [illegible] resources analysis.

[illegible]

[illegible]

[illegible]

5. [illegible]

The overall technical objective of the support of the [illegible] program is [illegible] to provide [illegible] coupled with a [illegible] problems stemming from this objective are [illegible]

1) Reliability of passive sensors in [illegible] and/or sources of supplementary [illegible]

2) Time cycles from [illegible] too long

3) Quality and speed of [illegible] improvement

4) Capability to integrate [illegible] subsystem [illegible]

5) Improved resolution of all [illegible] improved [illegible] of all non-imaging [illegible]

6) Capability to operate under [illegible] inadequate.

6. Recommendations

The following actions to support [illegible] technology advancement are recommended:

1) Increase funding for exploratory development by [illegible] present funding for a total of [illegible] per year.

2) Increase advanced development to a level of [illegible] by FY 56.

3) Construct five new facilities and [illegible] at a cost of approximately [illegible].

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

2. [illegible]

a. Night and Low-Light-Level Photo [illegible]

In the next few years [illegible] be improved in the whole photo system [illegible] will be the conception [illegible] base developments, particularly [illegible] trying out other additional possibilities [illegible] sources from those presently available [illegible] the rapid advances in [illegible] that the [illegible] progress there [illegible] reason to believe that light sources [illegible] high amplitudes and high speed [illegible] [illegible]. When coupled with [illegible] chloride a photosensitivity [illegible] techniques also will play an important [illegible] [illegible] resolution needs for purely passive [illegible] amplification with no [illegible] prospects are not encouraging for [illegible] high speed, and high resolution at low [illegible] because of the requirement for long exposure time.

b. Electromagnetic Spectrum

A trend toward utilizing more of the electromagnetic spectrum in photography will be apparent. [illegible] basis for establishing [illegible] capability in order to [illegible] an effective means for obtaining target keys at low altitudes. The near IR, perhaps out to 1.5 microns, will be useful in improved camouflage detection film and target keys.

Table 101-2. Recommended Receptor Locations

Name	Coordinates	Elevation Above Ground	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

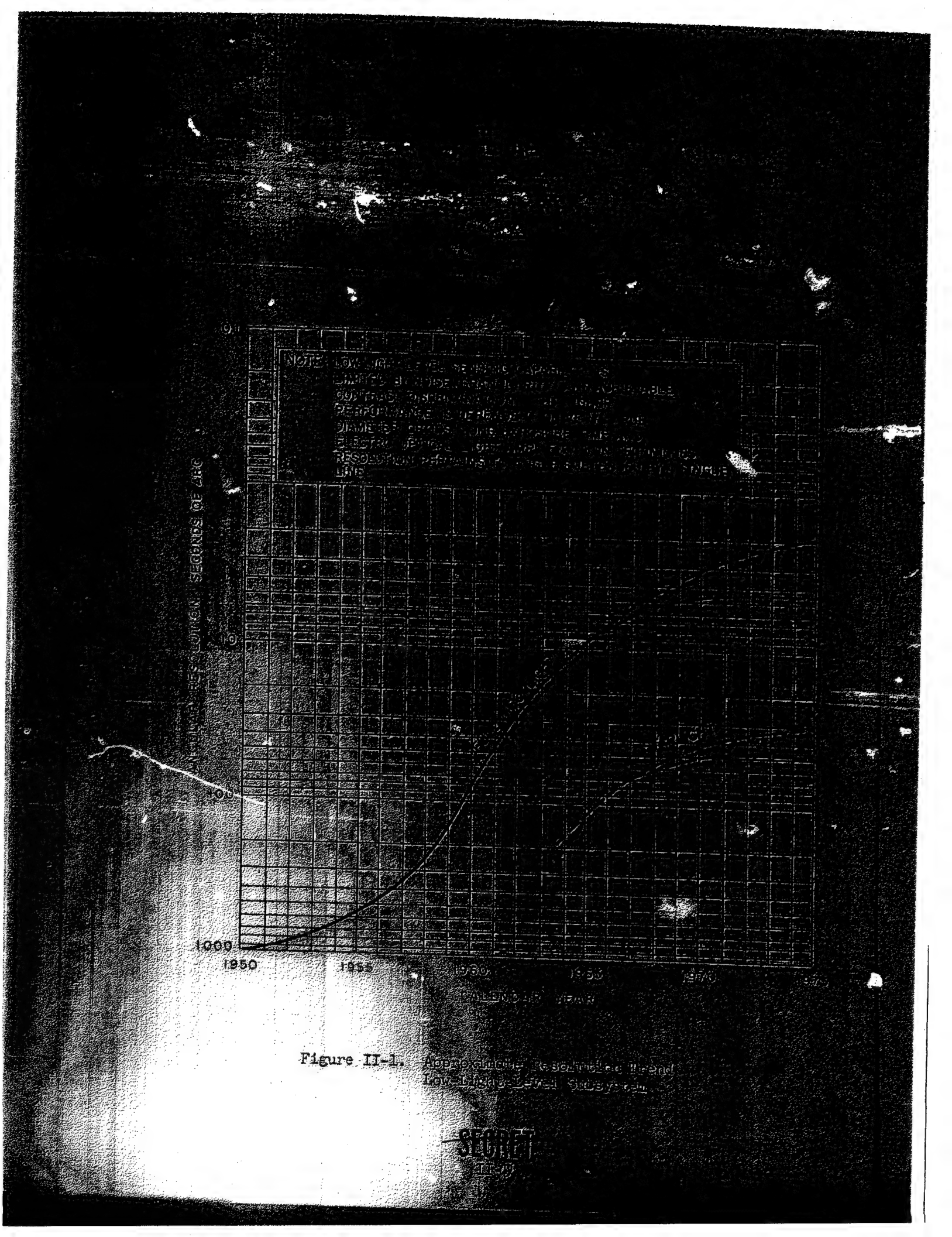

Figure II-1. Approximate Resolution Trend Low Light Level Subsystem

[illegible]

[illegible]

[illegible]

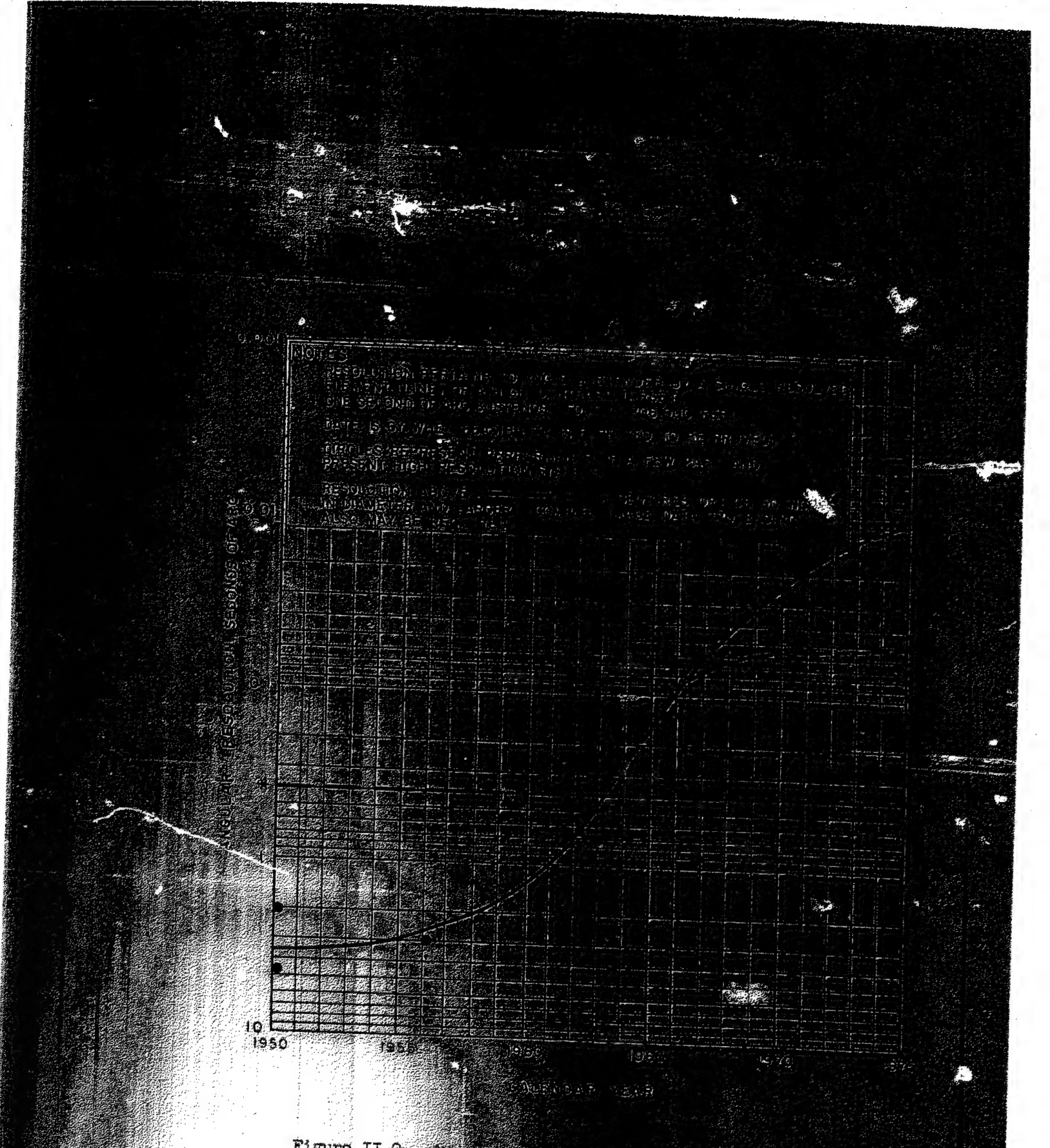

Figure II-2. Approximate Angular Resolution Trend, Photographic Systems

Figure II-3. Error Trend, Angular Steadiness, Verticality, and Image Motion Compensation

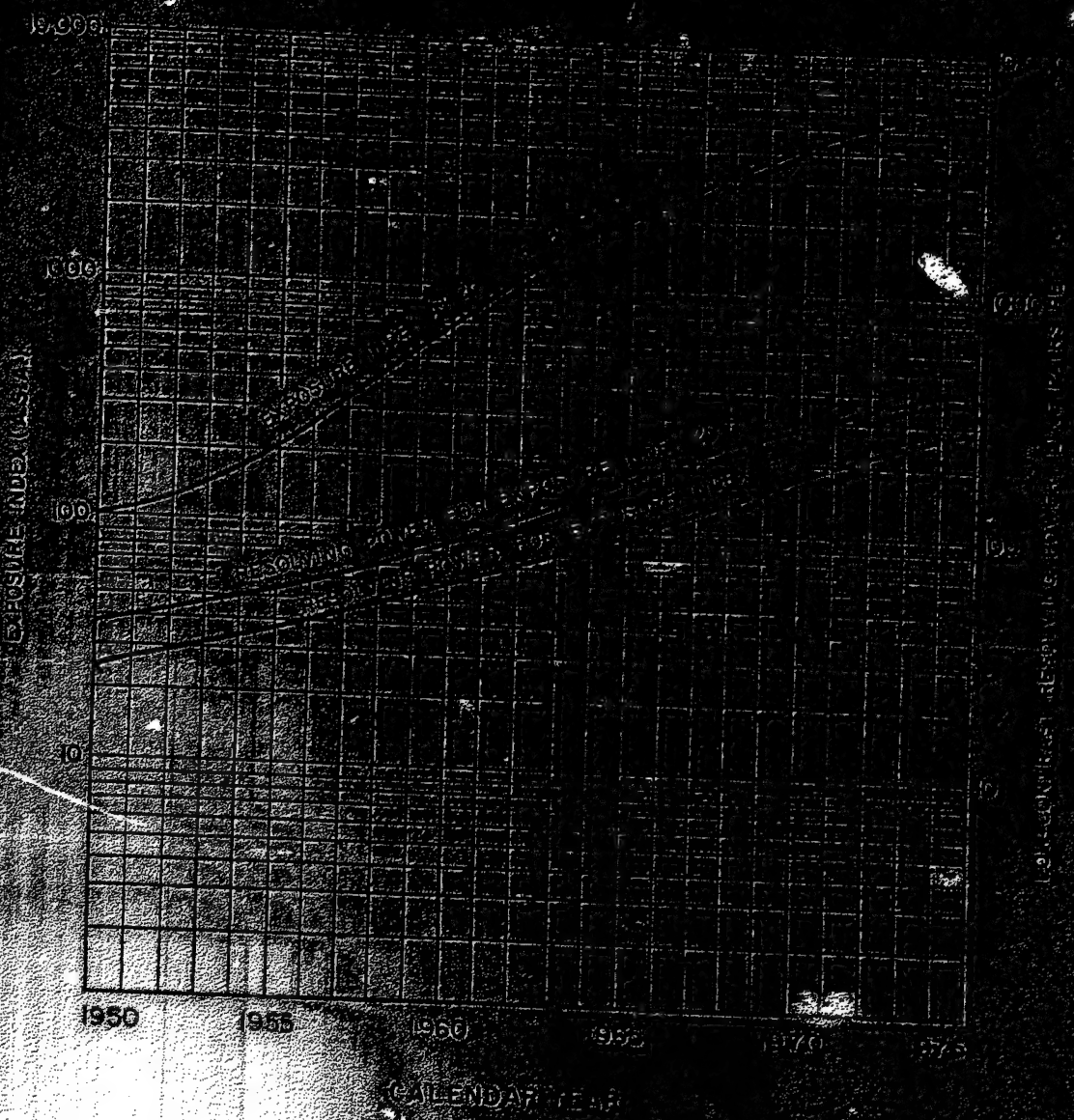

Figure II-4. Approximate Resolving Power and Exposure Index Trends, Photographic Synchronized Recorders

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[illegible]

4) Emphasis

The area in photography most [illegible] low-light-level recording [illegible] lent that advances in [illegible] be necessary for research and development [illegible] photographic technology [illegible] achieved. More surveillance [illegible] weak links in the photo recording [illegible]

All factors contributing to the [illegible] will need continued [illegible] research, optics, IMC, [illegible] 1970 should be:

1) [illegible]

2) Very long [illegible] and [illegible]

3) [illegible]

4) [illegible]

5) More convenient [illegible]

Methods of camera control [illegible] for [illegible] test and evaluation [illegible]

e. Laboratory Development

The following laboratory development [illegible] should be undertaken

1) Night-time photography [illegible] sources, particularly [illegible] the detection of [illegible] high-yield photography should be [illegible]

2) Wide-spectrum camera [illegible] detection (ED) using [illegible]

3) Atmospheric studies on both [illegible] on haze, particularly for [illegible]

4) New lens designs, optical-glass [illegible] control, test, and evaluation [illegible]

5) Camera controls capable of [illegible] pointing, focusing, shutters, and [illegible]

6) Higher-resolution [illegible] films, and new uncovered [illegible] imaging, dry processing, [illegible] and high resolution [illegible]

Photo-subsystem analysis and evaluation should be conducted on both theoretical and experimental bases with emphasis on new analysis and measurement techniques and on optimization of [illegible]

Although the Corporation [illegible] programs, [illegible] of these programs should be [illegible] by [illegible] approximately $1,750,000.

b. Advanced Development

Advanced development [illegible] photo subsystems [illegible] and experiments resulting [illegible] advanced development projects are [illegible] as follows:

1) [illegible] systems [illegible] mode, [illegible] mode. Total cost would be [illegible] order of $5,000,000.

2) A [illegible] resolution [illegible] operation [illegible] camera mode with [illegible] could be used [illegible] values could [illegible] wide-angle and [illegible] could be used. [illegible] sequence [illegible] done [illegible] order of $3,000,000.

3) Low-altitude [illegible] flying below [illegible] would be on the order of $750,000.

4) A high-cycle [illegible] filtration [illegible] be applicable to the [illegible] Total cost would be on the order of [illegible]

5) A multipurpose [illegible] panoramic, strip, or frame mode. Total cost would be on the order of $1,000,000.

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b. [illegible]

[illegible]

[illegible] image tubes [illegible] visual region of the spectrum [illegible] opened up the possibility of [illegible] red and ultraviolet regions. [illegible] been displayed on [illegible] recorded on photographic film [illegible] operate also [illegible] speed [illegible] on inexpensive film or tape [illegible] recorded. Thus recent [illegible] the photocontacts replaced by [illegible]

Another family of related [illegible] slides and uses light sources [illegible] resolution performance. Among [illegible] are rotated high-intensity light [illegible] wide 3-dimensional data [illegible] flash bombs, cartridges, lamps and [illegible] lamps, magnesium flares, etc., and [illegible]

The discussion of photomultiplier [illegible] applies to electro-optical [illegible] in that they face photosensitive [illegible] electronic signals. These [illegible] forming [illegible]

1) Photoelectric cells: [illegible] optical systems [illegible] in a scanning mode. [illegible] high degree and are [illegible] application [illegible] and frequent complexity of the [illegible] with IR systems.

2) Image Orthicons: Image-orthicons [illegible] yield the highest [illegible] having an equivalent [illegible] posure index of approximately [illegible] fast as photographic film [illegible] relatively low resolution [illegible] poor contrast discrimination [illegible] approximately 1-in.^{2} [illegible] constitute the basis of many image-angle [illegible]

Electro-optical techniques [illegible] display, although the problem of [illegible] deterioration of geometric [illegible] is in electronic form, and [illegible] data link or to electronic data processing [illegible] redundancy. Readout video [illegible] niques have been developed [illegible] such as clouds and industrial [illegible] mission (Ref. Section II.G).

Figure II-5. Astrometric Resolution Trends
Electro-Optical Subsystems

2. Trends

Trends relating to development of electro-optical detectors are developed and illustrated in Figures [illegible] and [illegible]. [illegible] tape. Figure [illegible] indicated anticipated performance of [illegible] systems which incorporate optical [illegible], [illegible] and image data processing [illegible]. Expected performance in conjunction with [illegible] is shown in Figure [illegible]. [illegible] of the most probable beyond 1967. [illegible] that time will depend on resources expended [illegible] and [illegible] of present exploratory developments, [illegible] and requirements. A great deal is expected of the [illegible] lasers, etc. Optical radar is a definite possibility [illegible] be possible to apply this technique to the problem of [illegible] marine detection. Trends in this last mentioned [illegible] predict at this time.

3. Problems

Future development of electro-optical [illegible] will depend to a large degree on discoveries and studies in solid state physics. Better materials with suitable characteristics for high resolution and sensitivity as well as techniques for [illegible] very small spot sizes for high resolution and sensitivity are needed. Lasers having fast pulse repetition rates are needed. Measurement methods for consistently producing [illegible] devices and materials are a further problem area.

C. Emphasis

1. Exploratory Development

Exploratory development on improving image resolution and sensitivity should be continued and without sacrifice for producing [illegible] resolution hard-copy prints requires further work. Additional exploratory development to improve light amplification and image intensification devices and techniques should be conducted using both the image tube and the image orthicon approach. New techniques for image enhancement, discrimination and data filtering with spectral and spatial filtering should be investigated. New applications of photo tape as image storage and processing techniques should be examined for application to other sensors such as IR and radar. Development of applicable laser techniques, both CW and pulsed, should be accelerated, and the search for laser codes to match the single frequency of a laser light source should be emphasized.

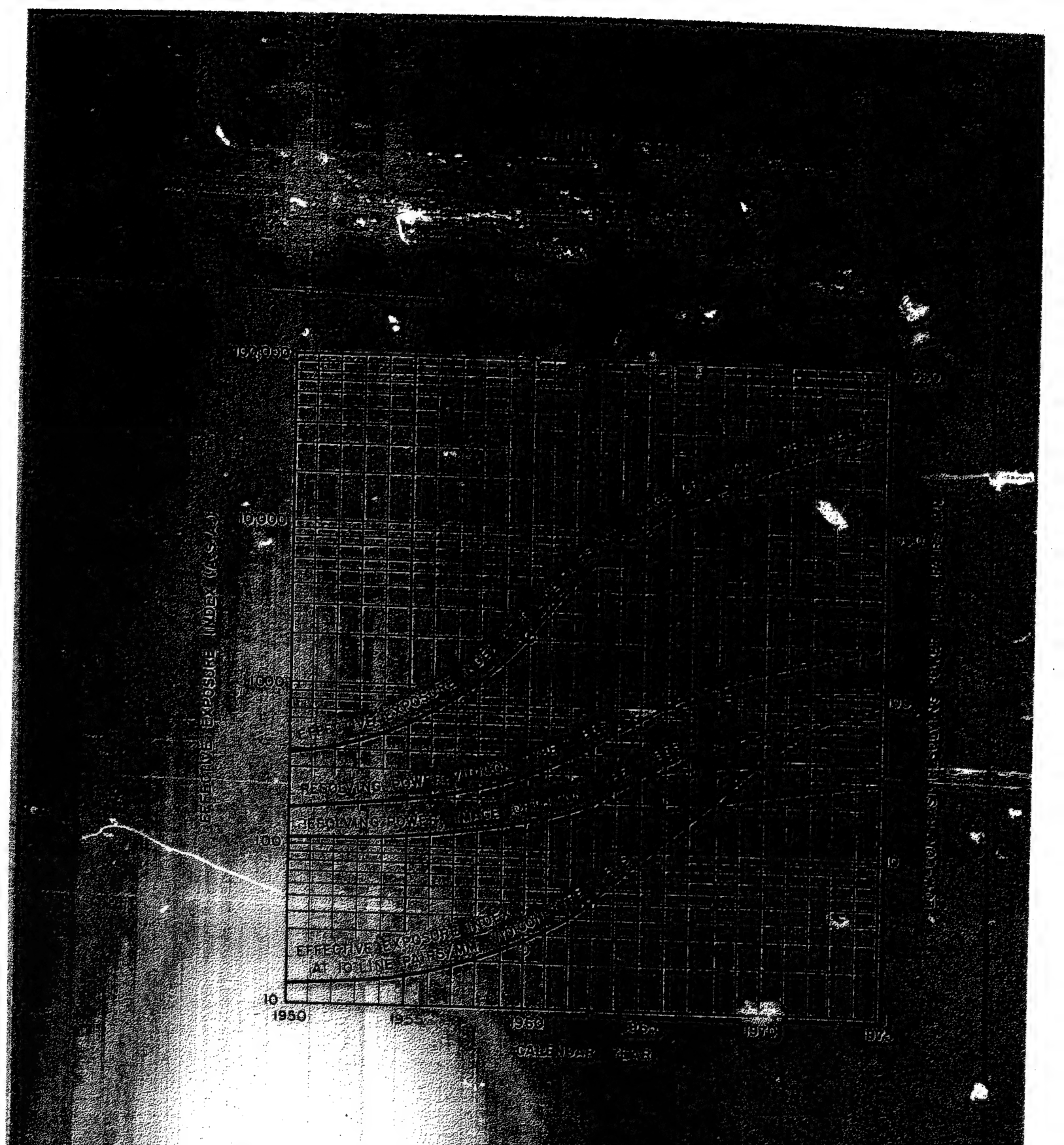

Figure II-6. Approximate Exposure-Index and Resolving-Power Trends, Image-Orthicon and Vidicon-Type Tubes

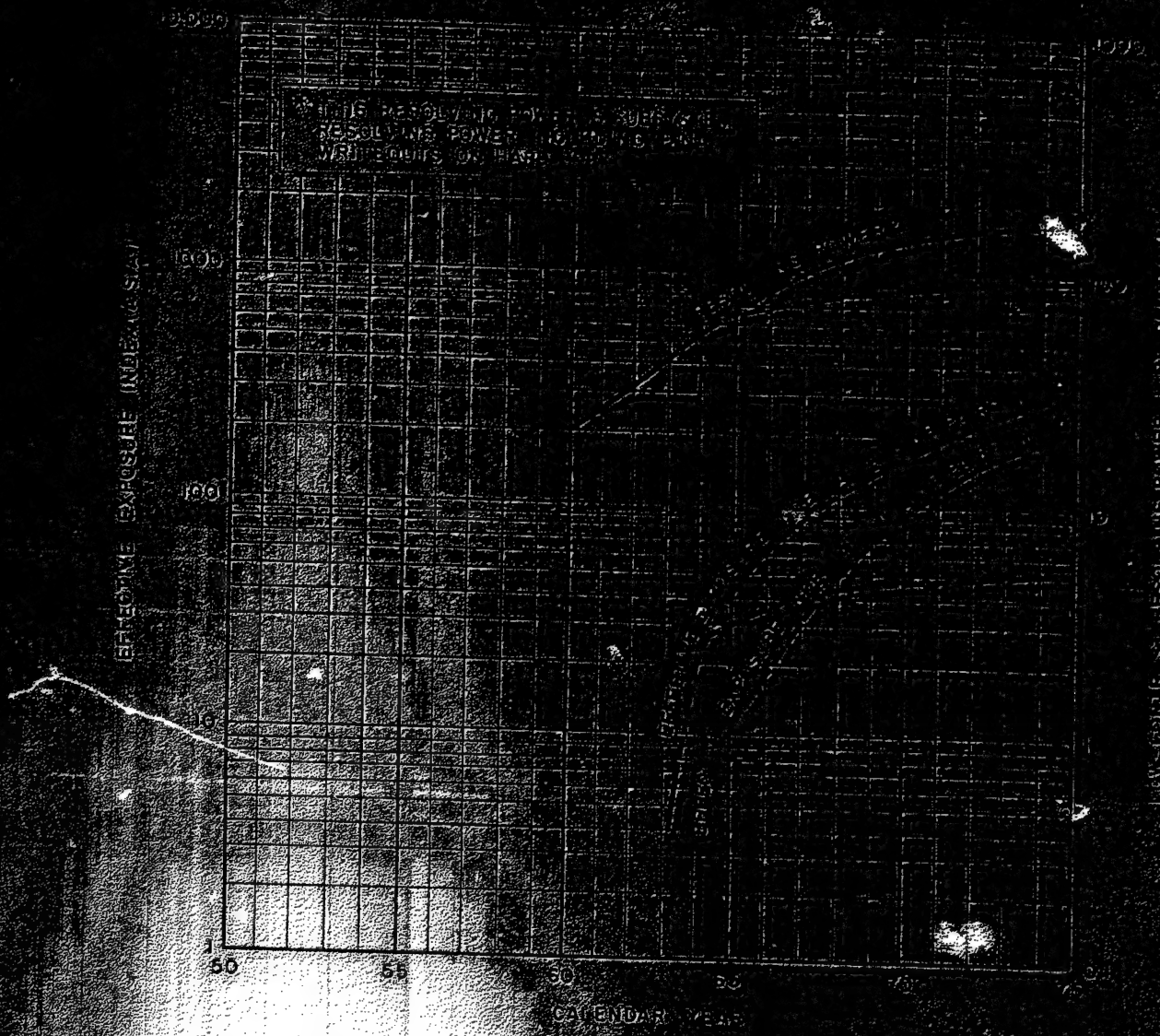

Figure II-7. Approximate Exposure Index and Resolving Power Trends, Electro-Optical Photo Tube

Although work in this area [illegible] the manpower should be [illegible] $750,000.

[illegible] Advanced Development

Investigation of the following advanced [illegible] should be conducted on an [illegible] and [illegible] and [illegible] and [illegible] and broadband sources.

1) Low-light-level [illegible] would provide [illegible] of recent advances [illegible] illumination. Perhaps [illegible] order could be employed. [illegible] entity covered [illegible] considered ready for advanced [illegible] order of $2,000,000 would be required.

2) A photo-tube subsystem for [illegible] also provide a low-light-level [illegible] would have a 2.5" x 2.5" [illegible] approximately 30 to 100 [illegible] order of $2,000,000.

3) The introduction of photo tubes [illegible] manufacturing technology. [illegible] merits of commercial resources [illegible] laboratory technology to the [illegible] required for subsystems [illegible].

4) A real-time photo-edge camera and [illegible] two advanced-development [illegible] ment may be considered available [illegible] tively at costs of $800,000 and $2,000,000.

[illegible]

[illegible]

[illegible]

Table III. Performance of Manufactured Detectors

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] detectivity normalized to unit detector area [illegible] of the detectivities of IR sensitive [illegible] made with the black body radiator at 500°K and [illegible]

Table III-4. Internal IR Image Tubes

Tube Type	Scattering Layer Type	Approximate Spectral Response (microns)	Operating Temperature (deg K)
IR Phosphor Tube	Phosphor	[illegible]	300° K (ambient)
Thermionic	Photocathode	[illegible]	300 (ambient)
IR Converter Tube	Photocathode	[illegible]	300 (ambient)
IR Modified Tube	Phosphor	[illegible]	[illegible]
IR Modulator	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

(2) Porous Plug-on Cooling. [illegible]

(3) Thermoelectric Cooling. Cooling devices based on the Peltier effect [illegible] electric energy is added to the system. [illegible] the number of stages required [illegible] practically large. [illegible] practical application of Peltier cooling devices seems to be limited to the region around 200°K.

(4) Radiation Cooling. [illegible] exchange in a space environment. [illegible] tion temperatures in space is low enough to serve as an alternate [illegible] cable for achieving the desired results by this means. [illegible] market that equilibrium temperatures of about 200°K can be [illegible] this way. This limited capability is not [illegible] systems.

(5) Solid Coolants. A type of cooling [illegible] direct-contact systems discussed above uses the [illegible] to produce cryogenic temperatures. The major [illegible] nance of low pressures above the solid. [illegible] 30-lb system weight [illegible] of cooling for one year can be obtained using solid methane at 170°K as a coolant. A hydrogen system [illegible] simulated heat load at 14°K for a system weight of about [illegible] to develop a 99% methane system are [illegible] technique has been of primary interest in [illegible] but its use has not been programmed for manned spacecraft systems.

(6) Closed-Cycle Cryostats. Various closed-cycle cryostats have been tested. A low-capacity (0.5-W) cooling system [illegible] several stages has achieved a temperature of [illegible] 99°K. However, its present design does not have sufficient cooling capability for use in [illegible] detector arrays, where 1.5 to 5.0 W would be needed. Two other such devices have been built and successfully used for cooling [illegible] in airborne operation. These provide 26°K temperature in approximately ten minutes. One of these devices is being developed for use [illegible]

c. Window Materials

[illegible]

1) Germanium - [illegible] and will [illegible] from 1 to [illegible] microns.

2) Irtran-2 - Irtran-2 [illegible] microns, [illegible] Irtran-2, and its [illegible] properties are quite satisfactory.

3) Gallium Arsenide (GaAs) - [illegible] Since gallium arsenide [illegible] from 1 to 15 microns [illegible] has been used. This material [illegible] a window at temperatures above [illegible].

4) Other Materials - A number of [illegible] materials are suitable for [illegible] or curved surfaces [illegible] band are to be used. [illegible] above should be considered [illegible] excellent Irtran-2 [illegible] disc or dome. No material [illegible] in operational hypersonic [illegible] beyond 15 microns.

d. IR Reconnaissance Subsystems

The Reconofax VII and the AN/UAS-5 are two IR reconnaissance subsystems that will meet tactical requirements [illegible] have a resolution of about 2 to 3 mrad [illegible] thermal resolution of about 0.3°C operating at a V/H of 1 to 1½ rad/sec.

High-speed/low-altitude IR reconnaissance techniques [illegible] a resolution of 1.0 mrad with a thermal resolution of about 0.3°C over a field of view of 140 degrees at a V/H of 1.0 rad/sec.

Very-high-altitude/low-speed IR reconnaissance techniques which provide an angular resolution of 0.5 mrad with a thermal resolution of about 0.3°C also are available. No suitable window material is available for

[illegible]

[illegible] systems operating [illegible]

[illegible] resolution [illegible]

[illegible]

[illegible]

[

[illegible]

[illegible] Cooling

[illegible]

[illegible] Windows

[illegible]

[illegible] Subsystems

[illegible]

[illegible] UV Techniques

[illegible]

3. Problems

Problem areas in IR/UV technology include:

1) Application of solid-state [illegible] to provide satisfactory linear arrays and mosaics.

2) Stable uniform photosensitive layers and [illegible] techniques for imaging tubes.

Figure II-9. Approximate Resolution Trend, Attached Subsystems

SECRET
Ill-31

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Although work in the above areas [illegible] manpower on these programs [illegible] approximately [illegible]

[illegible] Advanced Development

[illegible] should be given to development [illegible] techniques resulting from the above [illegible] gram as well as the advanced [illegible] previously discussed in Sections [illegible] should be given to development [illegible] to integrating these subsystems with other [illegible] and auxiliary equipment.

1) A very high altitude [illegible] subsystem [illegible] for IR reconnaissance from space [illegible] Although this subsystem would be [illegible] advanced, it would incorporate [illegible] Detectivities. An angular resolution [illegible] elution between 0.1° and 0.3° [illegible] would be on the order of $900,000.

2) A low altitude IR subsystem [illegible] reconnaissance from low altitude [illegible] subsystem should have an angular resolution [illegible] mrad, thermal resolution of 0.3°C and a [illegible] least 2 rad/sec. This capability should be [illegible] with near-real-time (less than 0.1 sec) display [illegible] photo-tape, and linear-array or mosaic detectors could possibly be incorporated [illegible] development by [illegible]. Development cost would be on the order of $900,000.

3) A program should be initiated to provide a compact reliable closed-cycle 5-w capacity cooling system which [illegible] reach and maintain equilibrium temperatures by 25 to 30°K and of 4.2°K.

[illegible] HIGH-RESOLUTION GROUND [illegible]

[illegible]

[illegible]

[illegible]

[

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] moving at a minimum radial velocity of [illegible] knots [illegible] a mile.

2. Trends

a. High-Resolution Ground Mapping (Synthetic Radar Code Language)

An estimate of present and future [illegible] resolution [illegible] Fig. 10. The resolution and range [illegible] have not been [illegible] established and the calculations [illegible]

The estimates for the 1965/1970 period are [illegible] cannot be forecasted by that time. The [illegible] aerodynamic vehicles, [illegible] and a capability of mapping [illegible] 2-in. [illegible] data for display to an operator or [illegible] able and approximately 95 [illegible] or less. [illegible] imately 10 [illegible] and.

In the 1967 time period resolution [illegible] resolutions from a 150-n mi altitude [illegible] Swath width at about ambiguities would be [illegible] ground processing of the signal would probably be required.

By approximately 1970 it is expected that [illegible] would have been proved feasible [illegible] aerodynamic vehicles. [illegible] doubt because of the smaller depression angle and [illegible] viewed and the resulting shadowing [illegible] angles are more favorable and larger antennas can be used. Although larger antennas are desirable to obtain [illegible] they also can introduce an undesirable characteristic. To obtain [illegible] resolutions in long synthetic arrays [illegible] is necessary to accomplish focusing, but this can be accomplished only up to the point where the resolution is one-half of the real antenna length. This limit may be reduced by dividing the antenna aperture into [illegible] and then processing the signal. However, this technique has also been fully investigated nor has its feasibility been proved.

Figure II-10. High-Resolution Radar Technology Trends

SECRET

[illegible]

[illegible]

[illegible]

b. Airborne Moving Target Indicator

The need in MMI is an increase in range capability of [illegible] and the capability to discriminate relatively large moving [illegible] by 1970.

2. Problems

The operational basis of radars employing synthetic aperture techniques is that the vehicle is flying along a straight line course or a very predictable path. In the case of the [illegible] course the angular motion is caused by vehicle instability, [illegible] placed into the doppler history which [illegible] processing for the antenna to achieve the expected resolution. It has been the practice in the past to begin accelerometers on the antenna to sense this unwanted motion and to insert compensation into the radar to achieve the high resolution required by airborne [illegible]. Such compensation probably will be necessary [illegible] around the use of high quality inertial platforms and accelerometers placed at or near the antenna to accomplish this [illegible].

Positional accuracy of the detection [illegible] can be affected by several factors. For instance, when the vehicle is assumed to be [illegible] a straight path but the course deviates [illegible] build-up period (the time required to compute the doppler history) for the synthetic aperture, a relative [illegible] occur if compensation is not introduced. The [illegible] as a function of range is approximately equal to the ratio of the unexpected velocity component normal to the assumed straight path and the velocity along the assumed straight path.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] to improve [illegible] to gain the increased performance [illegible] must be overcome [illegible] more on [illegible] [illegible] operation.

4) Microwave Thermal Generation Sensors - The [illegible] microwave thermal sensors [illegible] and have undergone [illegible] considerable [illegible] width of the antenna [illegible] ing in resolution [illegible] of sensor will not perform [illegible] powerful [illegible] of [illegible] element [illegible] [illegible] and investigations will be necessary to [illegible] progress.

5) Foliage Penetration - Techniques involved in penetrating foliage should be investigated.

6) AMTI - The study of AMTI techniques should be [illegible] to provide capability to deal with the following conditions.

a) Aircraft speed up to Mach 3.0.

b) Detection of ground vehicles moving as slowly as [illegible] knots.

c) Resolution of destroyer [illegible]

d) Ranges to 100 n mi.

7) General - To obtain more design freedom, increase resolution, range, and swath width without use of multiplexing [illegible] concepts for the overall radar are required. There [illegible] need for new technology for generating the microwave [illegible] well as for a means of obtaining [illegible] average power levels. Wind [illegible] to limit resolution with present concepts [illegible] new and less restrictive approaches must be [illegible] present concepts may not [illegible] in the electromagnetic [illegible] may contribute useful information.

[illegible]

(b) [illegible]

[illegible]

9. Advanced Development

The 665A program includes development of [illegible] devices. However, it does not include development of [illegible] devices [illegible] and contribution [illegible] should be considered are [illegible] processed information.

The 665A development program should be [illegible] data. The results of [illegible] technology in energy detection, [illegible] lessons, which will form a basis for [illegible] 1965, funding should be increased by [illegible] equivalent to about $2,500,000 for the 1965 [illegible]

[illegible]

[illegible] Airborne Communications and Signal Intercept Equipment

(1) [illegible] - [illegible] normally used [illegible] Power, weight, and space [illegible] Ordinary aircraft will [illegible] [illegible] to install [illegible] only [illegible] and justified by changes in the [illegible] and intelligence requirements.

(2) Receivers

(a) Sensitivity - In general, receiver sensitivity (maximum detectable signal) is not a serious problem. [illegible] are more severe. Noise figures range from 4 db at [illegible] to 17 db at [illegible]. Sensitivity ranges from -79 to -[illegible] dbm. In the case where the signal to be intercepted is directive (i.e., beam or [illegible]), [illegible] could be usefully employed. In general, [illegible] pulsed can provide sensitivity to [illegible] receivers.

(b) Bandwidths - Bandwidth requirements for general purpose [illegible] communications receivers do not normally exceed 20 kc.

(c) Scanning/tuning - Both continuous and [illegible] mechanical and electronic scanning are utilized. [illegible] previously (Ref. Section III 3.1.a).

(3) Recorders - Standard [illegible] and a [illegible] are used with additional channels provided for [illegible] digital data such as frequency, time, bearing, [illegible], and key operator [illegible]. Wideband [illegible] are used to provide a 40-sec delay while decisions regarding a particular intercepted signal are made.

(4) Displays - Activity displays showing frequency and time of activity are controllable to display segments of the total spectrum of coverage. Total coverage is from 50 to 1500 Mc, and [illegible] 100-Mc segments may be displayed. Frequency and other [illegible] needed numeric data may [illegible] special [illegible] (Nixie) tubes are displayed. When extensive remote control of equipment is utilized, special lighted control panels with pulsating operator prompting [illegible] are [illegible].

Ground-Based UHF Sensors

(1) Antennas

(a) Gain

VHF

1-Helix Array	13 db (50-100 Mc)
28-ft Parabolic Reflector	20 db (100-300 Mc)
Log-Periodic	15 db (50-300 Mc)

UHF

60-in Parabolic Reflector	19-20 db (300-550 Mc)
Conical Reflector	8 db (300-550 Mc)

SHF

1-, 8-ft Parabolic Reflectors	35 db (1.7 Gc)
6-ft Parabolic Reflectors	35 db (2.1 Gc)
Horn Reflector	20 db (1.8 Gc)

(b) Scanning/Tracking - Many ground-based UHF sensors are capable of 360-deg coverage. Positioners, stabilizers, and tracking devices are used. Search antennas often use sector scans to increase probability of intercept. Present scan rates vary from 1 to 4 rpm. Maximum tracking rates are only a few deg/sec, but this is satisfactory for present applications.

(c) Location Accuracy -

Below 50 Mc	4 percent of range
Above 50 Mc	Less than 1 percent of range

(2) Receivers - Crystal video, tuned radio frequency (TRF), and various superheterodyne types are being used and frequencies from 100 to 18 Gc are being covered. Below 1 Gc the receivers are noise-limited by the ambient temperature of the view of the antenna lobe. Above 1 Gc internal noise provides the limit upon the system noise figures. Present UHF receivers have noise figures in the 6- to 9-db range. Minimum detectable signals range from -144 to -174 dbw/m^2.

(3) Recorders - Video [illegible]

(4) Displays - Displays [illegible]

d. Ground-Based COMINT Sensors

(1) Antennas - For target [illegible] and to provide the necessary [illegible] support for this [illegible] requirements for better D/F accuracy have [illegible] the types and characteristics of the [illegible] antenna components. [illegible] with accuracy of 1 deg at 50 Mc and less than 1 deg above that frequency.

(a) Gain

VLF/MF	
75-ft vertical wire loop	Up to 1000-ma effective gain Up to 150-ma effective gain
HF	
2- to 30-Mc doublet, beverage, sloping vee, rhombic, and large circularly-disposed antenna arrays (CDAA)	2-15 db
VHF	
Yagi, corner reflectors, CDAA,	5-12 db
UHF	
Same as VHF plus parabolic reflectors.	Up to 25 db (determined by dish size [illegible])
SHF	
Same as VHF.	Up to 30 db with present [illegible] used dishes

(b) Scanning/Tracking - [illegible]

(c) Receivers - [illegible] 1950. The vast majority of the receivers are [illegible] channel narrowband-video [illegible] or wideband reception is required, [illegible] and operated to provide [illegible] and single-seeking receivers [illegible] operational conditions.

(d) Sensitivity - Receivers used for [illegible] are designed to operate within a few db of the [illegible] 100 Mc and within a few db of the [illegible] frequencies. As VHF, panoramic receiver noise figures average 10 db, and are off, 4 db. VHF noise figures are [illegible] by atmospheric noise.

(e) Scan Rates - Much of the present system [illegible] manual tuning and signal recognition of the emitter is a time-consuming process at present. AFC motor voltage-tuned magnetrons and [illegible] selected bands from 200 Mc to 100 Gc. But microwave receivers can reportedly cover a range of 4 Gc in 20 nanosec, and digitally-tuned receivers can be placed on frequency in less than [illegible] used to [illegible] frequencies up to 500 Mc. Scan tuning [illegible] could not be fully exploited without [illegible] operational conditions.

(f) Bandwidths - Any communications signal bandwidth which is [illegible] automatically transmitted is susceptible to reception. Most signals are in the low and medium bandwidths and are readily accommodated by the ground [illegible] system. The bulk of present requirements are bandwidth within [illegible] bandwidths. Data systems do not exceed 20 Mc. One operational wideband reception system in the [illegible] band looks simultaneously at a portion of the spectrum 840 kc wide.

(3) Recorders

(a) Types - Voice, data, and video magnetic tape recorders are available. Ink tape recorders for automatic morse, teletype, and photographic recorders are also used.

(b) Bandwidth - Photographic and magnetic-tape recorders capable of recording 4-Mc bandwidths are available today.

[illegible]

(a) Regarding time [illegible]

(b) [illegible]

2. [illegible]

[illegible] General Technology Trends

Some important trends [illegible] technology [illegible] time [illegible] be developed and utilized.

Figure [illegible] shows the overall general [illegible] 1975 and is based on a 100-channel [illegible] 10-fold decrease in size is expected to be achieved in the 1965/1975 time period.

Reliability trends are [illegible] ments, particularly where [illegible] trends show that a 90-percent reduction [illegible] 1975.

Reliability in terms of mean time between failures (MTBF) [illegible] containing 1000 active components is shown in Figure [illegible]. Such advance-ments could achieve nearly two orders of magnitude improvement in mean-time failure by 1975 if the technology is applied.

b. Location Accuracy

Depending on platform characteristics, the accuracy of [illegible] location for airborne systems will improve [illegible] range from 2 Mc to 40 Gc. If great concessions are made in airframe plat-form characteristics toward satisfying electromagnetic compatibility objectives, this same accuracy might be achieved down [illegible] Accuracies of 3 to 10 percent may be possible, even [illegible] bands.

Use of phase measurement is being investigated for airborne location finding on a pulse-to-pulse basis. It shows promise of providing [illegible] accuracy in both azimuth and elevation. Sample [illegible] cover approximately octave bands. A breadboard system covering [illegible] being fabricated.

Figure II-11. Miniaturization Trends in Electronic Components

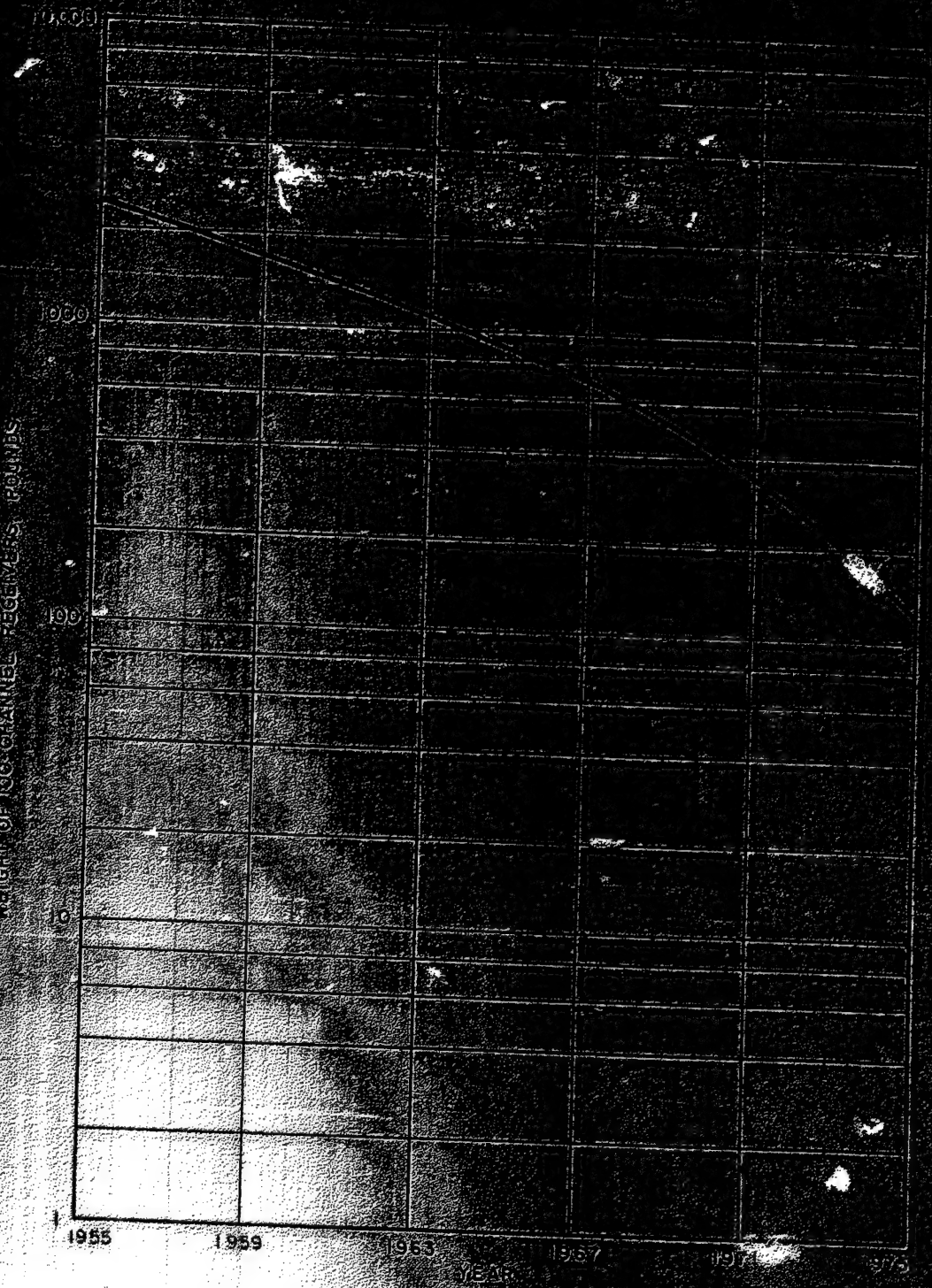


Figure II-12. Weight Trends in Electronic Equipment

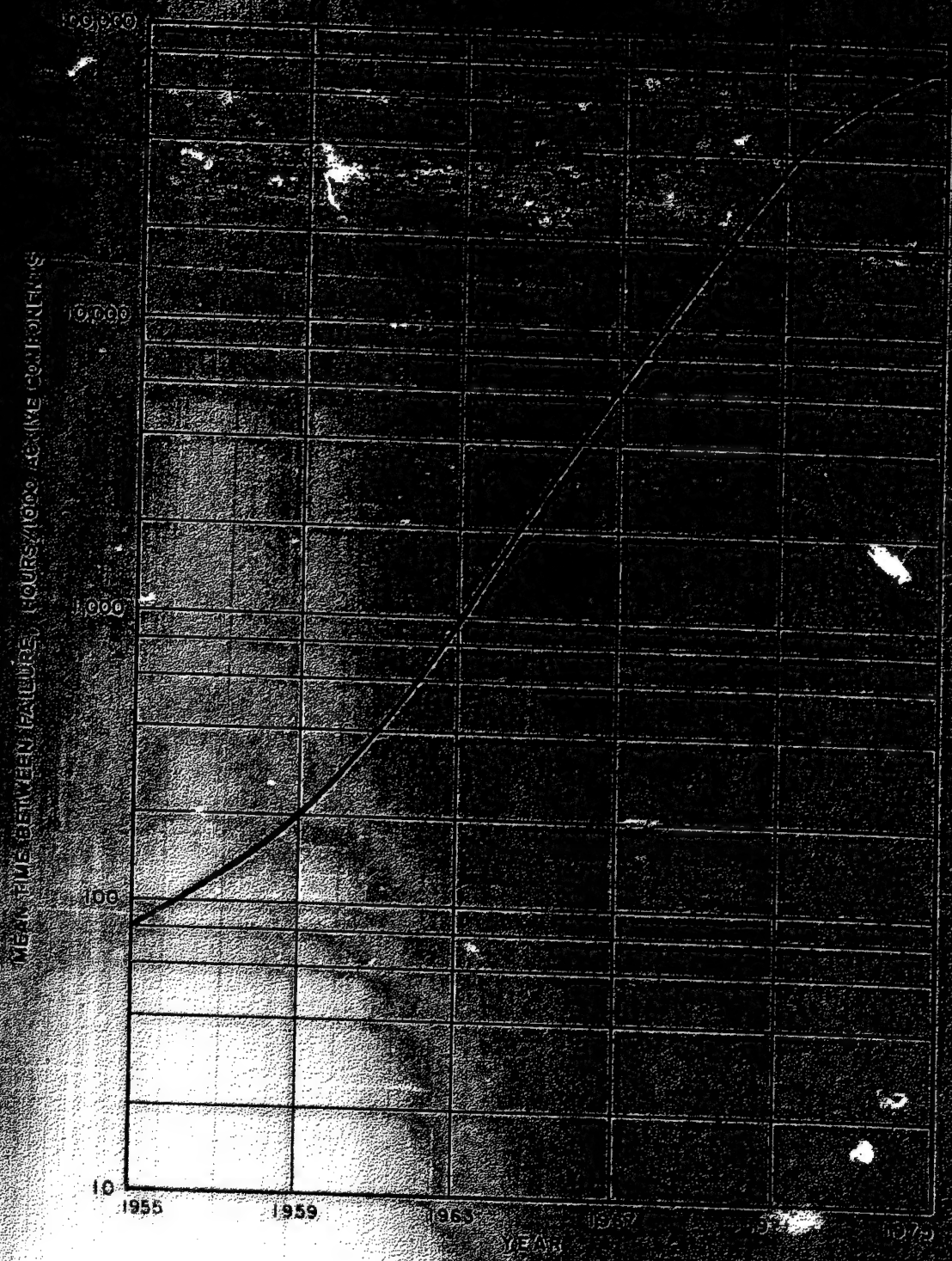


Figure II-13. Reliability Trends in Electronic Equipment

[illegible]

[illegible]

c. Antennas

Antennas at X-band scanning 360 deg at 200 rpm have been experimentally demonstrated. Electronic scanning has been demonstrated in research, but has not found wide-spread application. Antennas which are required to track moving targets have mechanically or automatically [illegible] mechanical or electronic beam control.

Frustable, tunnel, or plasma antenna techniques as used as [illegible] active/passive reradiation devices may find application in attempts to provide improved emitter location accuracies, reduction in aperture, improved efficiency, etc., over all types of [illegible] magnetic sensor systems. In addition, adaptive techniques allowing the antenna to compensate for multipath reflections caused by the [illegible] appear feasible today.

d. Receivers

General trends in receiver weight, space, and reliability technology should be similar to those previously described for electronic technology in general. In some portions of the spectrum, one can [illegible] noise figures of less than 2 db can be achieved using cryogenic techniques.

Recording

[illegible]

The magnetic recording up to 10 [illegible] and rapid development up to 50 [illegible] A capability of 15 [illegible] signal-to-noise ratio (S/N), and from 3 [illegible] be available in the immediate future.

Electron bombardment may [illegible] recording of [illegible] over a 1-to [illegible] speed to 1 Mc. Such [illegible] necessary to provide [illegible] of signal [illegible] over very wide bands.

As recording periods become shorter and [illegible] reduced (i.e., toward binary), recording devices [illegible] operations of delay lines and magnetic core [illegible] has high-density storage capacity (10^9 to 10^{12} [illegible]).

Displays

The present trend is toward more automatic [illegible] of [illegible] data to magnetic-tape recordings. An [illegible] the intercept analysis consoles so that the operator can [illegible] comments regarding any unusual characteristics [illegible] or equipment. Solid-state technology promises to reduce the [illegible] weight and volume of displays and associated control circuitry by a factor of 10 to 20 by 1970, and as much again by 1975. Large-[illegible] color displays with self-contained storage/regeneration capabilities are [illegible] development or study. In one experiment, operator [illegible] tion between crowded signals was increased 100 to 200 percent [illegible] color display techniques. These are available and could be applied to intercept systems existing today.

[illegible]

[illegible]

[illegible]

The Intercept System could have the necessary capability and flexibility to cope with the 1970 electromagnetic environment. Techniques are now available which economically provide such functions as:

1) Antenna beamwidth and sidelobe [illegible]

2) Clustering of the received pulse [illegible]

3) Skipping those portions of the data which are [illegible]

4) Instantaneous recognition of pulses belonging to a particular radar pulse train.

By these techniques and applied to the signal intercept data processing problem the required on-line capability can be realized.

3) Problems

Important problems related to EW sensors include:

1) Extension of range coverage of present electromagnetic systems beyond line-of-sight.

2) Development of airborne capability for automatic, instantaneous, geographical location.

3) Providing of larger capacity [illegible] capability to uniquely identify specific emitters.

4) Providing capability for passive airborne tracking of [illegible] telemetry to determine launch and re-entry trajectories of long-range missiles.

5) Electromagnetic subsystems frequency coverage extension below 1 kc and above 40 Gc.

[illegible]

[illegible]

[illegible]

[illegible]

8) Improved receiver [illegible] to observe and measure eight-order radiation [illegible]

9) Development of methods and equipment for measuring the [illegible] and vertical radiation [illegible] of foreign transmitters.

10) Application of [illegible] techniques to increase reliability of information [illegible] quantity of information [illegible] be received, recorded, extracted, and disseminated.

11) Interception and processing of non-communication, [illegible] and incidental electromagnetic radiations from important military, scientific, and industrial complexes.

12) Application of miniaturization techniques and devices to the receiver subsystems [illegible] increasing cost or decreasing reliability.

13) Improved receiver linear dynamic range response from [illegible] 40-60 db range to 90-100 db.

14) Ultra-low-noise receiver development [illegible] cable to extended [illegible] ranges.

15) Development of ground-interface antenna techniques which minimize their detection by unfriendly forces.

16) Development of techniques for predetection decoding at the radio frequencies.

4. Emphasis

a. Exploratory Development

1) Extended-Range Coverage (Beyond Line-of-Sight) - Investigation of various phenomena as means for obtaining extended-range

[illegible]

[illegible] Coverage for [illegible] of [illegible] beyond [illegible] should be undertaken. Indeed [illegible] operation of [illegible] [illegible] [illegible] natural phenomena [illegible] elements such as [illegible] sporadic E layers (and [illegible]) [illegible] layers, and [illegible] (Faraday [illegible]) [illegible] over the present effort in these areas would be on the order of $900,000.

2) Rapid and Unique On-Line [illegible] - [illegible] of adaptive techniques to the [illegible] should be [illegible] pursued. It seems highly [illegible] that [illegible] in the future will require more [illegible] [illegible] function or purpose of the [illegible] [illegible] used in the targets of interest. The portion of [illegible] appears most promising for [illegible] area of adaptive techniques, [illegible] learning techniques, pattern recognition, [illegible] mining techniques. However, unless [illegible] need will exist long before the research [illegible] substantial benefit can be obtained. [illegible] effort will contain a cost increase on the order of $600,000 over the current program.

3) Extended Frequency Coverage - The [illegible] from [illegible] to 101 cps should be investigated to determine the [illegible] of parts thereof that would be most likely to be used due to [illegible] the operational advantages that would be offered to the user in specific situations. Developments of the necessary [illegible] techniques as indicated in order to cope with the areas most likely to be used. A 200% to 300-percent increase in effort over the present program will require additional funding on the order of $570,000.

4) Improved Location Accuracy - Synthetic and dispersed aperture systems will be required for better accuracy and inconspicuous ground-based antenna systems. The feasibility of providing distortion-free receivers to extract information which may be of specific use in the [illegible] location problem (e.g., phase information), should be investigated [illegible]

[illegible]

[illegible] per year for approximately [illegible] years.

a) [illegible] frequency range from [illegible] for [illegible] Mc. [illegible] RF-4B. [illegible] parts to [illegible] "Hart" (hull effect) [illegible] suggested. They [illegible] region to [illegible] other system complexity [illegible] antenna system [illegible] caused by the [illegible] the use of plasma [illegible] should be investigated [illegible] Although [illegible] to be realized from this [illegible] tasks will require a [illegible] $70,000.

b) Ground-Based System [illegible] investigations are [illegible] particularly [illegible] certainly of the [illegible] for ground-system [illegible] restrictions may be [illegible] radios below 1 Mc, especially [illegible] also must be improved. [illegible] cent of range are [illegible].

5) Laser Intercept - The problems facing electromagnetic sensor systems in this area must be organized and analyzed before prototype hardware requirements can be prepared. A combination of sensors and artificially [illegible] isms may be required. Photon-beam [illegible] non-interruptive non-detectable intercept capability from locations orthogonal to the laser beam. It is estimated that these efforts will exhaust costs on the order of [illegible] during the first year after [illegible] and $[illegible] the second year.

6) Adaptive System Organization - [illegible] sized to provide [illegible] and [illegible] of the [illegible] be subject to [illegible] system [illegible] defensive [illegible] combat [illegible] operation of system resources [illegible] information from which [illegible] will be terminated and that all [illegible] from the system will be immediately eliminated.

Concomitant with the above is the dual [illegible] of the opportunities for [illegible] system design and [illegible] the ability [illegible] lat and polymorphic systems capabilities [illegible] for the future time. However, [illegible] on separately from the foregoing recommendation [illegible] tion on all pertinent aspects must be [illegible] each project. This investigation will [illegible] over the present program which is approximately [illegible] $350,000.

7) Radiation Intelligence - Studies are needed to [illegible] areas most likely to pay off in surveillance [illegible] radiations. From these studies, prototype hardware should be developed to exploit these radiations. All non-[illegible] byproduct and incidental radiations from military, [illegible] and industrial complexes should be considered. Costs of these studies will be [illegible] order of $100,000.

8) Pattern and Power Management - The present effort in this area now in progress under Project 1020 should be continued. Since resolution of these problems is critical to development of penetration aids and decoys, the work on this program should continue to be funded at a rate which will assure that efficient utilization can be realized. The present funding rate is considered adequate.

9) Miniaturization - Miniaturization and ultra-miniaturization should be pursued as a high-priority effort that is particularly applicable to receiving systems. An extensive program toward development of thin-film circuits and solid-state techniques as applied to intercept equipments will make the cost of these

[illegible]

b. Advanced Development

1) Airborne On-Line Data Processing. Airborne data processing techniques for on-line [illegible] location and/or characterization should be developed, and application of airborne computers and computer programs for processing all electromagnetic sensor data should be [illegible]. It is envisioned that adaptive and other advanced programming techniques such as pattern recognition will be required to [illegible] and to identify and track in cases where only or [illegible] considered parameters vary randomly or over complex patterns.

General purpose high-speed computers having [illegible] flexibility to respond to changes in [illegible] and [illegible] needed. Economy and small size as well as [illegible] between air and ground mobile versions should be especially emphasized. This development is [illegible] to [illegible] Ferret System and Project [illegible]. Development will cost on the order of $1,500,000 spread over a three or four year period.

2) Improved Location Accuracy. [illegible] applied antenna/data/storage [illegible] for the ground based equipment. Airborne configurations requires passive tracking capability to accuracies [illegible] 0.5 mrs in both azimuth and elevation. Desired range, velocity and acceleration information may be derived from angular measurements. The frequency range of primary interest for this purpose is between 2000 and 3000 Mc. Approaches which may be feasible are phased arrays and monopulse, but an exhaustive study should be made of all possible antenna techniques. It is envisioned that gyro-stabilized antennas will be required. This program will cost on the order of $3,000,000 spread over three years.

3) Reduction of [illegible] - [illegible] and operational testing [illegible] combination [illegible] equipment should be [illegible] years.

4) Ground Detection and Analysis of [illegible] - A complete system capability for [illegible] reveal the technical [illegible] of the art in [illegible] equipment should be provided [illegible] determine the gross parameters of the [illegible] versus time, power versus frequency, [illegible] program would cost on the order of $[illegible] over approximately three to four years.

5) Measurement of Higher Order Harmonic Variations - The problem of determining the feasibility of [illegible] evidencing interactionality in [illegible] this needs to be [illegible] ability to sample the [illegible] the accuracy required must be developed. This study program would cost on the order of $[illegible]17,000 for the first calendar year from go-ahead.

6) Air-Propagated Transceivers - Development of [illegible] and rugged consumable [illegible] for [illegible] emplacement is recommended. [illegible] and [illegible] wave transponders should be accommodated. This study will [illegible] costs on the order of $150,000.

7) Extended Range - As good as the results of investigations of extended-range techniques [illegible] in specific collection problem areas, development to provide immediate exploitation should be initiated. Costs will be on the order of $1,500,000 spread over three years.

8) Adaptive Techniques - Development and evaluation of adaptive techniques are needed to improve emitter location accuracy and to increase signal identification accuracy. Costs will be on the order of $750,000 spread out over three years.

[illegible]

[illegible]

[illegible]

[illegible] ionospheric propagation. A program [illegible] National Bureau of Standards [illegible] the degree of propagation [illegible] ionosphere [illegible] thunderstorms [illegible]

b) An analog-to-digital converter to convert 25-Mc video signals at 5,300 megabits/sec [illegible] is being [illegible] at the present time. This system will [illegible] gray levels. (Joint project)

c) An electrostatic photo-tube camera [illegible] has been developed which is capable of [illegible] and electronic readout of 25-Mc video [illegible] This development is [illegible] because the image is stored directly by electrostatic charges on a tape and can be read out by an electron beam without any necessity for developing film.

d) An investigation of wideband multiplexing techniques to send four 25-Mc video signals over the microwave channel is under way. Successful completion of this program would provide final verification of the [illegible] discussed above, which has four times more bandwidth than [illegible] required for transmitting the highest bandwidth (25-Mc) video signal available today.

e) An EHF communication system is presently under development, including transmitter, receiver, modulation/demodulation equipment, and dish-mounted transmitting antennas. Design goals are 5 w of transmitter power at 70 Gc and an information bandwidth transmission capability of 100 Mc. Search, acquisition and tracking problems with directive antennas in an air-to-ground environment will be investigated in this program.

4) Moon Bounce and Orbiting Dipoles. - Study for development of an airborne terminal with a 10-kw X-band transmitter, 30-in. parabolic antenna, antenna-pointing computer, and maser receiver is in progress. This should provide a terminal that is compatible with use of West Ford dipoles and the moon, which would provide a long-haul air-to-ground link at low transmission rates of 50 bps or less. This terminal would be usable without modification for active satellites, providing the antenna and system frequencies were compatible with the West Ford frequencies. The information rate of such a system could be 10 megabits/sec.

5) Unmanned Spacecraft - [illegible]

6) Secure Voice [illegible] - [illegible] system will provide a 100-[illegible]

7) USAF ACRP Secure Communication System - [illegible] system which [illegible] to [illegible] aircraft and 35 [illegible]

2. Trends

[illegible] real-time emphasis being placed on [illegible] for transmission of photographic and other information [illegible] tion of larger amounts of information over [illegible] through space and around the surface of the earth. [illegible] projection of wideband transmission based on [illegible] coupled with the inherent problems of [illegible] lems. This table summarizes the needs for such [illegible] and [illegible].

3. Problems

a. Wideband Data Transmission

1) Propagation Media - The limitations set by the propagation media may require multilocating of the Satcom Ground [illegible].

2) Synchronization - The high data rates place [illegible] requirements on data transmission timing synchronization. Another problems are line and frame synchronization. [illegible] in the system timing accuracies of [illegible] are required.

3) Aircraft Antenna Design - Transmission of wideband data from an aircraft requires a tracking capability to [illegible] stations or satellites. Acquisition of these vehicles [illegible] craft antenna and a second antenna [illegible]. [illegible] to this problem is anticipated in the near future.

Table III-5. Relayed Transmission Trends

Type of Operation	1970/1975 Capacity with Jamming at Beacon	1970/1975 Capacity with No Jamming
One-way, aircraft to synchronous satellite to ground Aircraft 1 kw, 1 ft Dish Satellite earth coverage 4400 w, 10 db antenna, noise figure Ground station 60 ft Dish System temperature 300° K	Two 10 kw per 60 db AJ process-ing with jamming from the attack type station	1.4 kb/sec 10 db S/N
Same as above, except satellite at 200-n mi altitude	600 - 3000 kw, 10 db AJ process-ing. Depending on type of jam-ming and processing	100 - 200 kb/sec Undetectable 10 db S/N
Transmission of sensor information from satellite to ground station Satellite [illegible] Ground Altitude 200 - 500 n mi Ground Station 60 ft Dish, 300° K	Does not apply when a jamming dome drives another satellite on an aircraft	200 kb/sec, Fo-cused 13 db S/N
Near bounce or orbital capsule Aircraft Power 10 kw, 10 db [illegible] Ground Station 60 ft Dish, 300° K	10 - 50 kw may be required to overcome a jammer at a distance of 1 kilometer or more	50 kb
Air to ground line-of-sight communication	600 kw - 10 kw	[illegible]

[illegible] Communication and Signal Design

[illegible]

b) [illegible]

[illegible]

c) Secure Voice Communications

Secure voice communications [illegible] spectrum. Transmission of these [illegible] not be reliable because interference [illegible] will limit the transmission [illegible] voice waveforms used to describe [illegible] describing adjacent bits(5). Some [illegible] be [illegible] A tracking antenna would be needed on an aircraft for [illegible] via a satellite.

e. Operational Incompatibility

In many operations interference caused by [illegible] communications. A multi-sensor aircraft will require a [illegible] ference and radiation analysis, [illegible] communications, navaids, etc.

d. Electro-Optical Converter

Electro-optical converters to utilize the [illegible] now being tested are not available.

e. Antenna Stabilization

Antenna or antenna-pattern stabilization will be required for wideband air-to-ground data links.

f. Cryptographic Security

Cryptographic security for air-to-ground [illegible] equipment. Subminiaturization techniques [illegible] chronization techniques are time-consuming [illegible] in a jamming environment. New synchronization and [illegible] niques should be studied and developed.

[illegible]

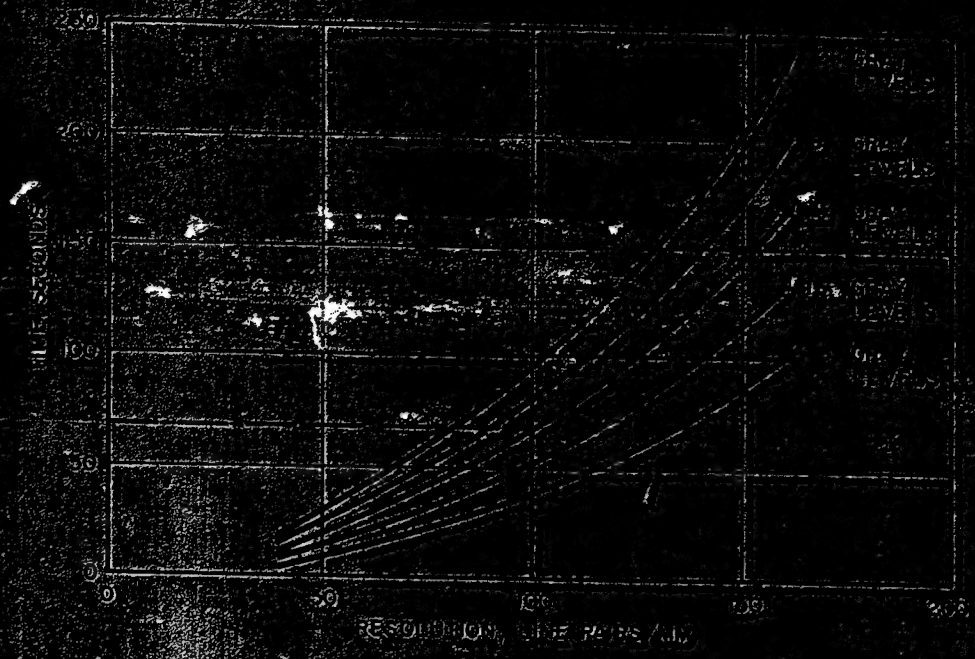
[illegible]

[illegible]

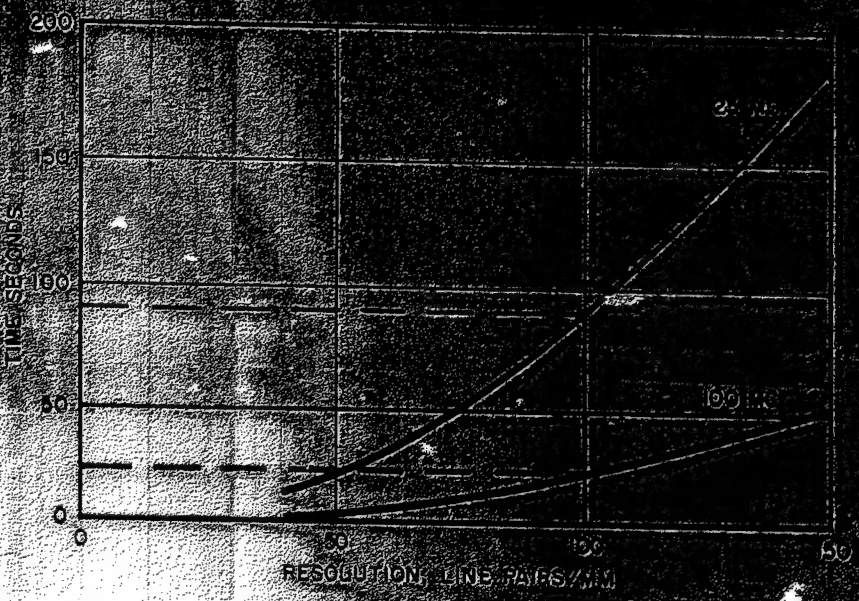
[illegible]

[illegible]

[illegible]



(a) Digital Transmission



(b) Analog Transmission

Figure II-14. Time Required to Transmit One [illegible] a Transmission Rate of 100 Megabits/Sec

[illegible]

[illegible]

[illegible]

[illegible] Ground Vehicle Communications - Development [illegible] standard forms [illegible] investigation [illegible] contractors [illegible] from ground to air, and [illegible] duplex operation [illegible] communications are [illegible] from 50 to 5000 bps. Development of multiple [illegible] presently [illegible] to be assembled for relay operations.

[illegible] Line-of-sight Wideband Transmission - More emphasis is required in the [illegible] program to provide [illegible] through phased [illegible] the air-to-ground [illegible] to permit [illegible] wideband signals. This package should be designed to [illegible] "piggy-back" with a future orbital vehicle. Increased emphasis should be placed on development of techniques to reduce the number of bits that are required to transmit radar or photo graphic information.

An orbital reconnaissance vehicle will require a [illegible] and control network for random or [illegible] sensor information. Emphasis for exploratory development in this area should be aimed at increasing the reliability of components in a space environment. The long-term problem of maintaining secure command and control is under investigation in other programs.

For COIN or limited-war applications, techniques should be investigated to provide lightweight tracking antennas, receivers, and data-processing equipment for the wideband systems.

A 50-percent increase in the funding of exploratory developments relating to data transmission will be needed during the 1965/1968 time period. This will be equivalent to approximately $800,000 per year.

[illegible] Advanced Development

1) [illegible]

2) [illegible]

3) [illegible]

4) Security - The advent of high-speed [illegible] processors will increase the problems of interference and radiation. Advanced development is required to provide overall system security. Applicable funding is included in foregoing items 2) and 3).

[illegible] Photo Processing

[illegible] Photo Reproduction

[illegible] Photo Reproduction Materials

[illegible] for the use of [illegible] photographic materials [illegible] design considerations, current and future [illegible] capability must be provided by gelatin silver halide emulsions. Typical emulsions [illegible] are such as the Eastman Kodak [illegible], [illegible], and [illegible]. These materials are [illegible] sensitive and [illegible] slow speed. Respective low-contrast resolution capabilities are 50, 160, and 500 lp/mm.

Except for very limited special applications, no photovoltaic materials [illegible] have the necessary characteristics [illegible] the gelatin silver halides. Current capabilities of some photovoltaic materials are [illegible] listed in Table II-6.

[illegible] High-Acuity Photo Reproduction

The conventional reproduction cycle is a four-step process involving [illegible] exposure of the original negative, the master positive, the duplicate negative, and the duplicate positive. Reference to quality in connection with discussion of reproduction technology always refers to the quality of the release positive.

In a precisely controlled laboratory environment 150- to 200-lp/mm low-contrast imagery can be reproduced with negligible loss of information content. In gelatin silver halide systems this is accomplished by [illegible] the information density [illegible] during production of the master positive. Systems using other materials can maintain this order of quality through contact printing operations. However, the machines are extremely bulky, contain very high-energy ultraviolet-[illegible] light sources, and require overly-sophisticated methods of cooling the lamps and collimating the light.

c. Photo-Processing in an Austere Environment

This type of processing capability is typified by the [illegible] portable photo laboratory to support OSR 405. This laboratory provides a highly mobile photographic capability designed for rapid deployment to worldwide locations. The laboratory will process 35-mm through 9.5-in. wide materials, contact print 5- to 9.5-in. materials, and enlarge 70-mm and 5-in. material two times (2X). The laboratory is capable of processing

Table III-6. Recommended Reproduction Materials

Material	Sensitivity (Exposure Index)	Resolving Power 2:1 Contrast (lp/mm)	Processing	Continuous Tone	Variable Contrast	Available
Gelatin AgBr	Blue/UV (10^{-2} to 10)	100-250	Wet	Excellent	Yes	Now
Vacuum-Evaporated Ag_2S	Blue/UV (10^{-2} to 10)	500	Simple Solution	Excellent	Yes	1966/1970
Diazo	Blue/UV (10^{-5} to 10^{-7})	600-1000	Wet	Good	No	1966/1970
Photochromic	Blue/UV (10^{-3})	100-200	Heat	Poor	No	Now/1970
Photo-Radical Dye	Red/Green (10^{-3})	600-1000	Heat/Dry	Good	No	Now/1970

Figure II-15. Approximate Low-Contrast Resolution and Trend for Reproduction Throughout Generations of Continuous-Tone Negatives

e. Processing in an Orbital Environment

During the 1970/1975 time period [illegible] techniques are [illegible] by [illegible] processing, [illegible] [illegible] [illegible]

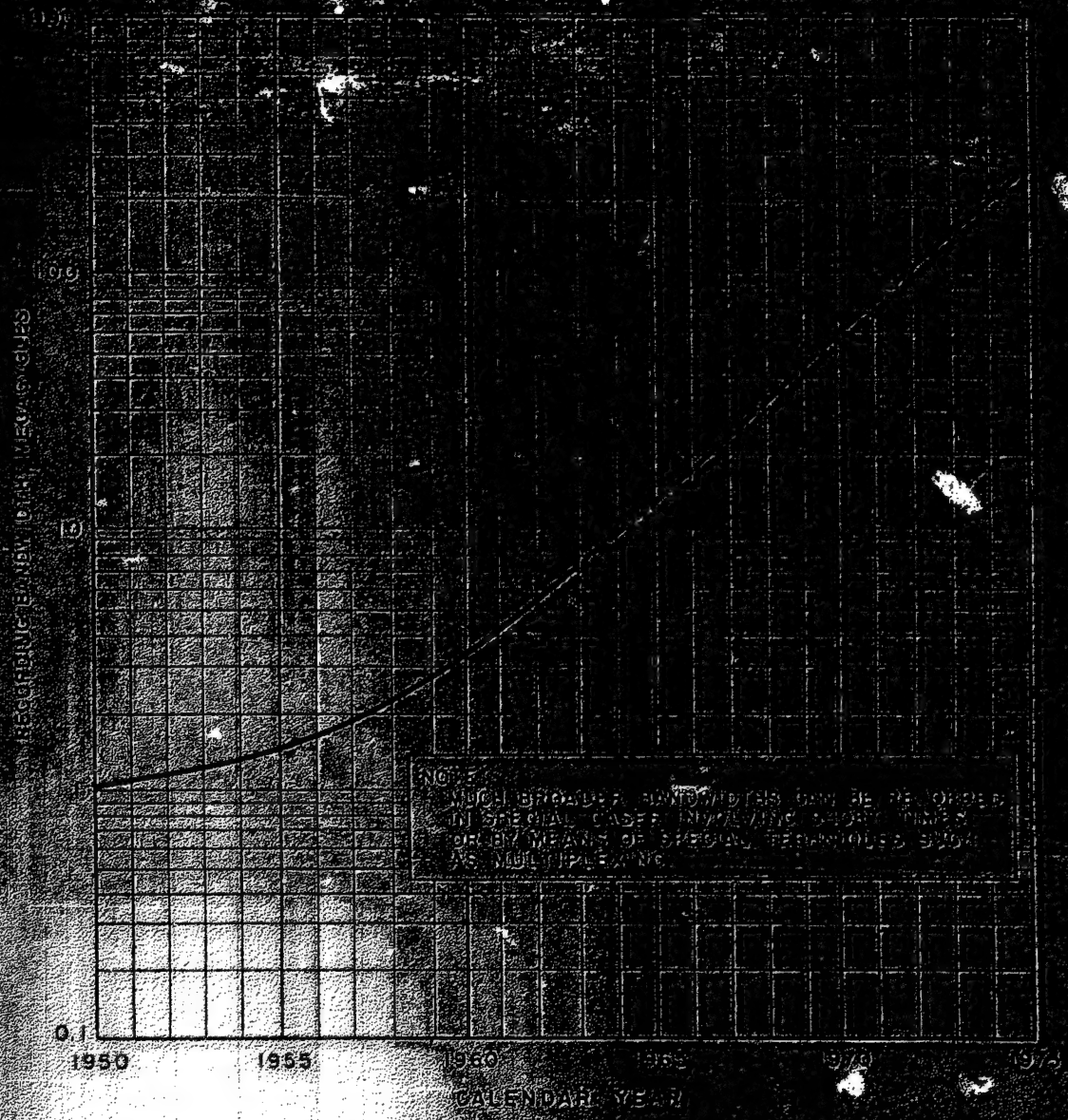


Figure II-16. Approximate Electronic Signal Bandwidth Recording Trend for Reconstructing Scanned Images

3. Image-Data Processing (Microdosimetry Optical)

[illegible]

3. Problems

a. Photographic Reproduction Materials

Contrast in gamma at unity, or less, [illegible] and producing homogeneous grain sizes are the main problems to be solved in making high-quality silver halide reproduction materials. The main problems to be solved in unconventional materials such as tracks and radiation-activated dyes are to increase their density range, provide a variable gamma around unity, improve uniformity of density, increase sensitivity, and improve stability of the photogram.

b. High-Acuity Reproduction

Precision lenses and reproduction equipment operating in an extremely clean environment and having tight tolerances for stability and temperature will be required. Increased speed of operation and completely automated computer-controlled reproduction operations are other areas that need investigation. More exact semi-automatic techniques to provide the requisite for complete automation and for better control of unconventional materials during the reproduction cycle must be developed, as well as extremely high-energy light sources tailored to the spectral sensitivity of the relatively insensitive unconventional materials.

c. Processing in Austere Environment

The major problems in this area are:

1) Providing simple, portable equipment for controlling the processing environment.

[illegible]

[illegible]

d. [illegible]

The main problems in this area are:

1) Providing means of real-time viewing images [illegible] preparation or data transmission.

2) Simplifying and miniaturizing the processing apparatus and techniques.

3) Providing a sound idea of [illegible] quality of processing. Quality must be comparable to that obtained by conventional ground-based machine processing.

4) Providing a high-quality dry positive that can be [illegible] that will be immediately available for interpretation when the vehicle lands. Quality must be equal to the [illegible] station product produced by conventional processing techniques. Quality for the secondary negative may be [illegible] degraded by the technique used to provide the positive. No post-development processing should be required.

e. Electronic Signal Image Recording

The major problems in this area are:

1) Providing energy sources and techniques which can be focused to very small points and which are suitable for modulating, scanning, and energizing media.

2) Providing electron-beam and light-source modulation techniques (0 to 100 percent modulation).

3) Providing electron beams of micron sizes and increasing densities which can be modulated and deflected from 5 to 10 mm without loss of focus.

[illegible]

[illegible]

[illegible]

[illegible]

3) High Quality Reproduction - [illegible]

4) Dry-Processing - [illegible] solving the problems of providing [illegible] time processing, and [illegible] Dry-processing techniques, [illegible] research and development [illegible] should be considered.

5) Electronic Signal Image Recording - [illegible] and techniques are required. [illegible] requirements for [illegible] requirements for much better image [illegible] make use conventional CRT [illegible] new approaches are not being pursued. [illegible] should be investigated inasmuch as no single technique or medium is expected to fulfill requirements for all applications.

6) Special Processing Techniques - Recent [illegible] work on restoration of photographic images has been highly promising. Additional support should be made available to improve these techniques and to develop methods for volume processing of computer signals.

Although work in the above areas is presently programmed, funds and man-power on these programs should be increased by 25 percent, which is equivalent to approximately $750,000.

b. Advanced Development

1) Reproduction Materials - Introduction of new types of reproduction materials will cause major problems in manufacturing technology. A major government or commercial effort will be required to

[illegible]

2) High-Acuity Reproduction - [illegible] high-quality [illegible] human being from the [illegible] reproduction subsystems [illegible] effecting orderly conversion to the use of these [illegible] [illegible] has been five years should be [illegible]. Cost will be on the order of $3,000,000.

3) Portable High Resolution TAC Reconnaissance Photo Reproduction Laboratories - Special TAC reconnaissance [illegible] tactical missions utilize high-resolution cameras. [illegible] sophisticated handling of film during [illegible]. Present effort on OSR-105 provides a portable processing capability for normal TAC missions. A [illegible] but also high-resolution capability needs to be developed. Cost would be on the order of $2,000,000.

4) Processing in an Austere Environment - Development of miniaturized processing equipment that will [illegible] problems and permit hand [illegible] should be emphasized. A high-acuity mobile processing capability [illegible] and continuous-process [illegible] equipment for color films to [illegible] low-altitude reconnaissance are required. Particular attention should be given to developing equipment that uses dry-processing techniques rather than solution [illegible]. Cost will be on the order of $1,000,000.

5) In-Flight Processing - Emphasis should be placed on a continuous program to develop in-flight processing equipment as new laboratory technology becomes available. Research in this area is currently being neglected. Cost will be on the order of $500,000 per year.

[illegible] to 4 years [illegible]
[illegible] using [illegible]
[illegible] TV, and other sensor [illegible]
[illegible] photography.

(b) Targeting and Cha[illegible]
[illegible]ting from sensor data and [illegible]
[illegible]ting and charting are p[illegible]
[illegible]ation and location of obje[illegible]
[illegible]graphy in a variety of form[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] lengths in [illegible] spectra. The [illegible] other targets [illegible] length to [illegible] the density of the [illegible] collected imagery.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] high [illegible]
[illegible] slopes [illegible]
as well as [illegible]
in this type equipment.

b. SIGINT Data Extrac[illegible]

Extraction of information [illegible]
involves several concepts [illegible]
the sensor, the type of sig[illegible]

Because of the high de[illegible]
important to provide [illegible]
to reduce the amount of [illegible]
primarily manual, with [illegible]

[illegible]

[illegible]

[illegible]

(b) Targeting and [illegible]

[illegible] in interpretation [illegible]

[illegible] targeting and charting [illegible]

[illegible] are expected to [illegible]

[illegible] subjective image [illegible]

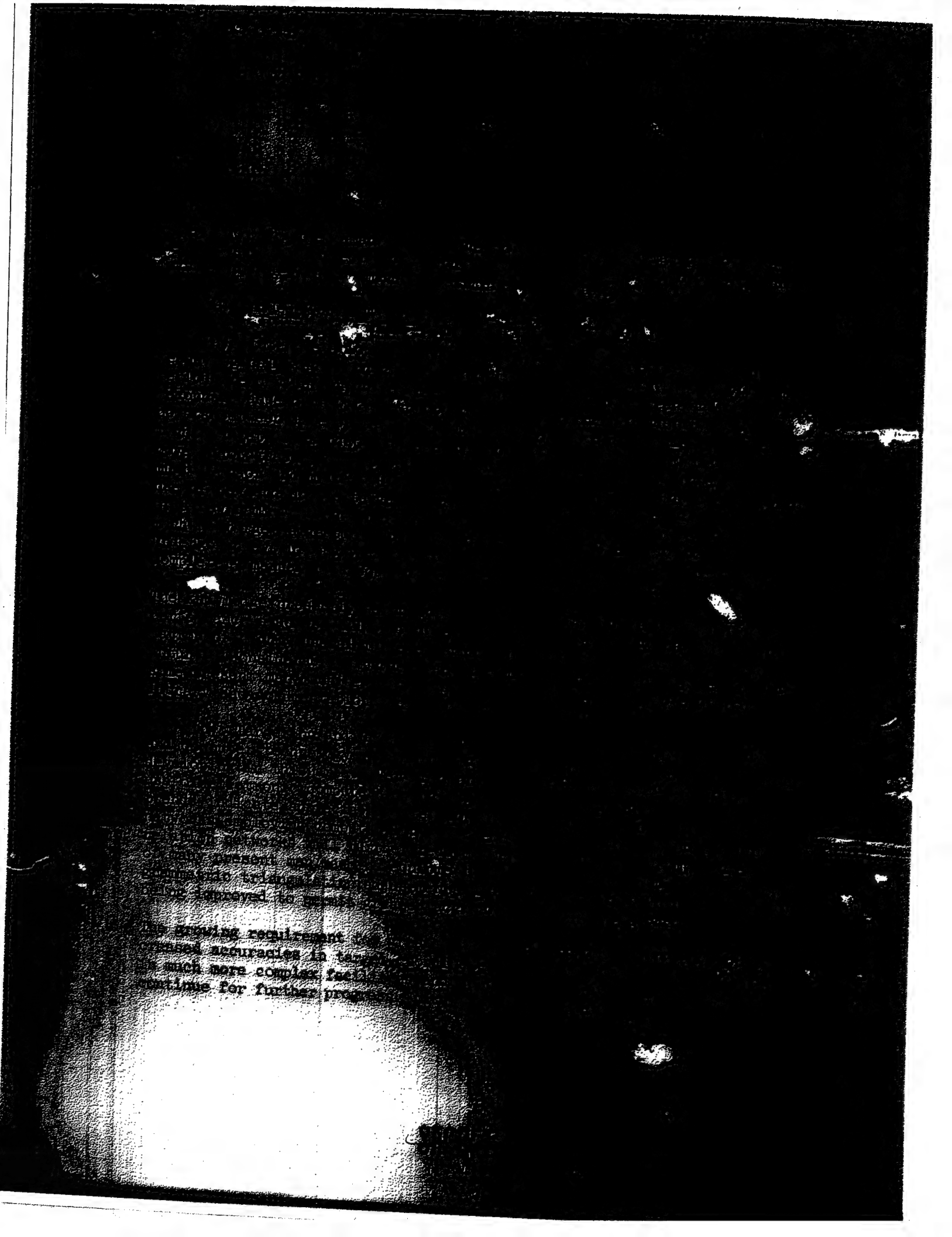
[illegible] support of both the interpretation [illegible]

[illegible] developing in season [illegible]

[illegible] for greater exploitation [illegible]

[illegible]/charting purposes. [illegible]

[illegible] proficiency will approach [illegible]



of target
nous
to insure
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Development
demonstrated
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difficult to
likely to be
than 50 percent of
attained by 1970.

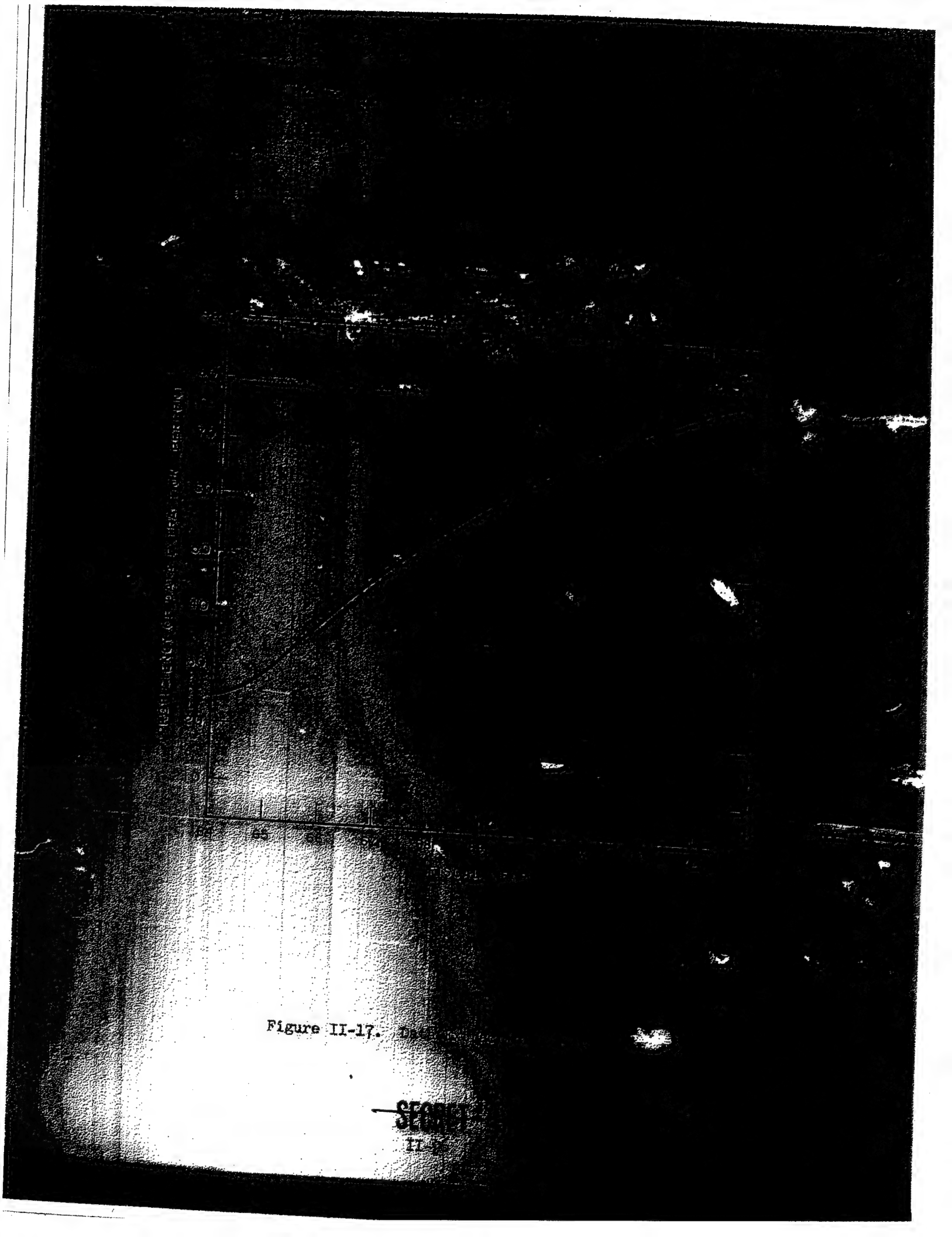


Figure II-17. [illegible]

[illegible]

[illegible]

[illegible]

Image Data Extraction

(1) Manual Techniques - [illegible]

1) Insufficient scientific [illegible] characteristics to [illegible]

2) Inadequacy of training [illegible] to foster highly profici[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

3) [illegible]

4) Quarter-[illegible]

5) Rectification of [illegible] data.

6) Rapid stereo and [illegible] for all sensor [illegible]

7) Rapid production of [illegible]

8) Rapid production of [illegible]

2) Techniques add [illegible]
speed and accuracy [illegible]
charting operations [illegible]
ing, cartographic [illegible]
network adjustment, [illegible]
image correlation, [illegible]
on the order of $2,0[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

2) [illegible]

3) [illegible]

4) [illegible]

5) [illegible]

[illegible]

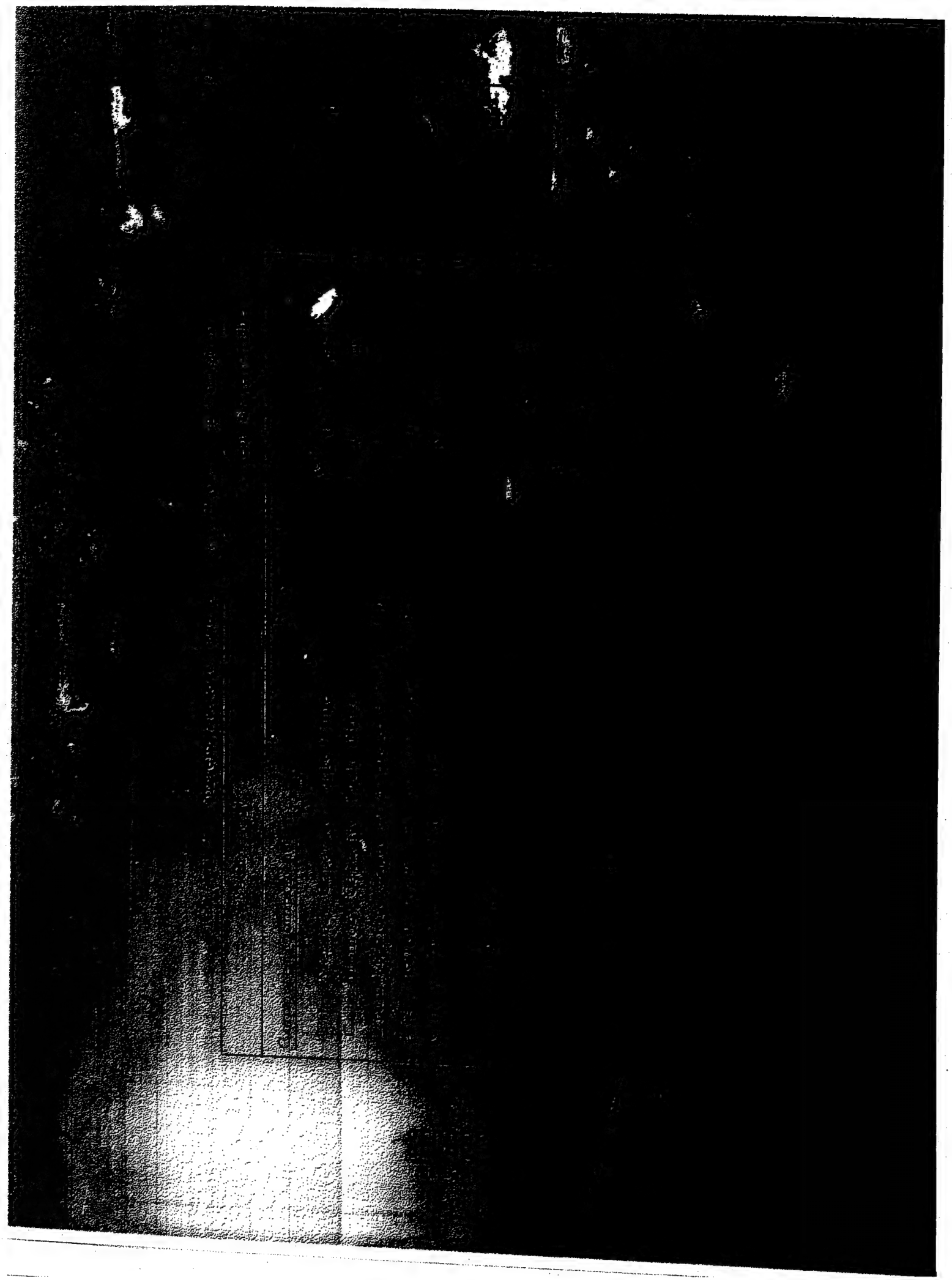
[illegible]

[

[illegible]

[illegible]

[illegible]



(b) Input Processing

[illegible] a large amount of [illegible] are embedded in [illegible] [illegible]able to machine process[illegible] [illegible]matting, and key punching [illegible] require substantial error [illegible] times required to accept a [illegible]

[illegible]

[illegible] extensively [illegible]
[illegible] discrepancies of query [illegible]
[illegible] of graphing [illegible]
[illegible] the results in one or [illegible]
[illegible] graphing method can be [illegible]
[illegible] capability appears to [illegible]
[illegible] graphical products.

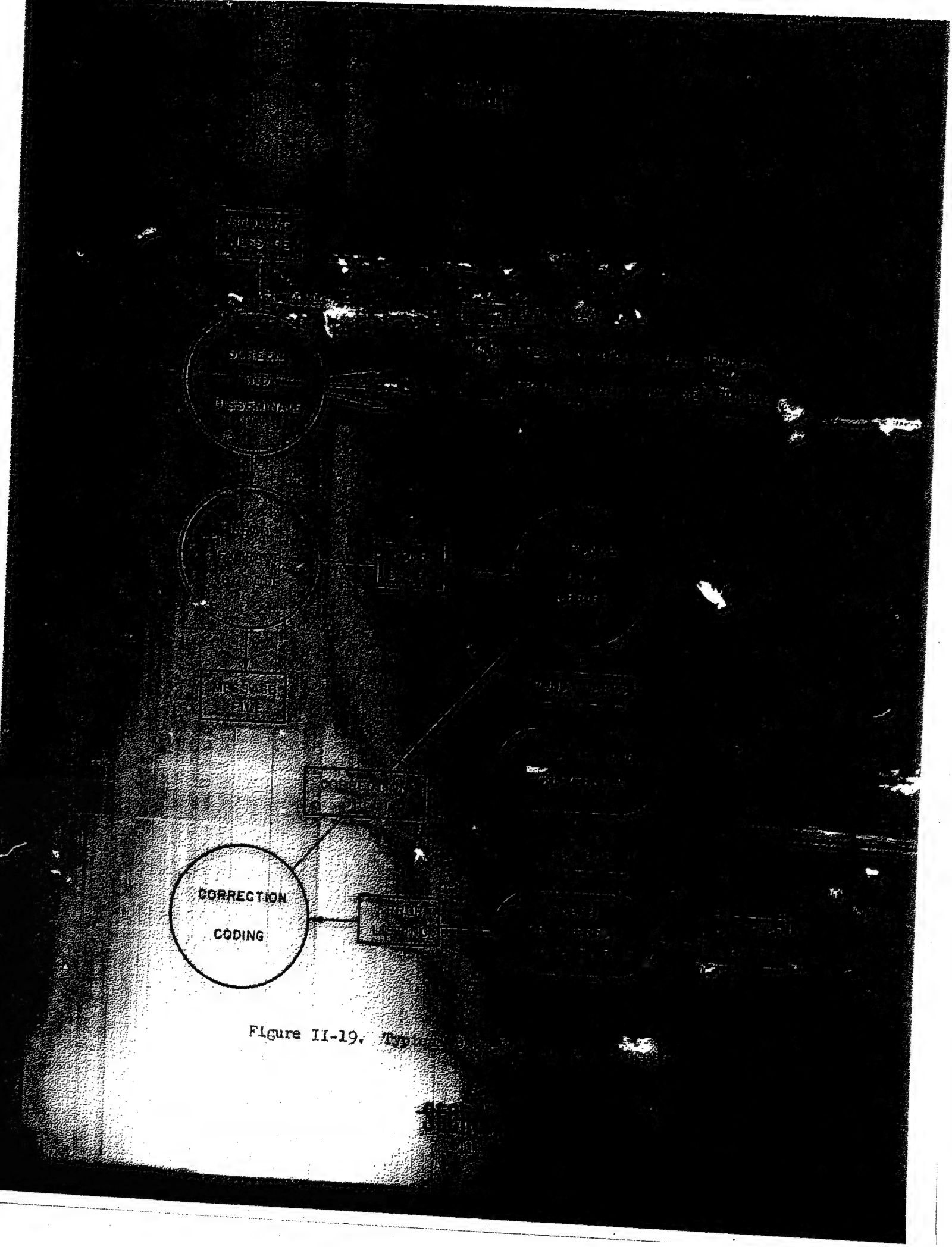


Figure II-19. Typ

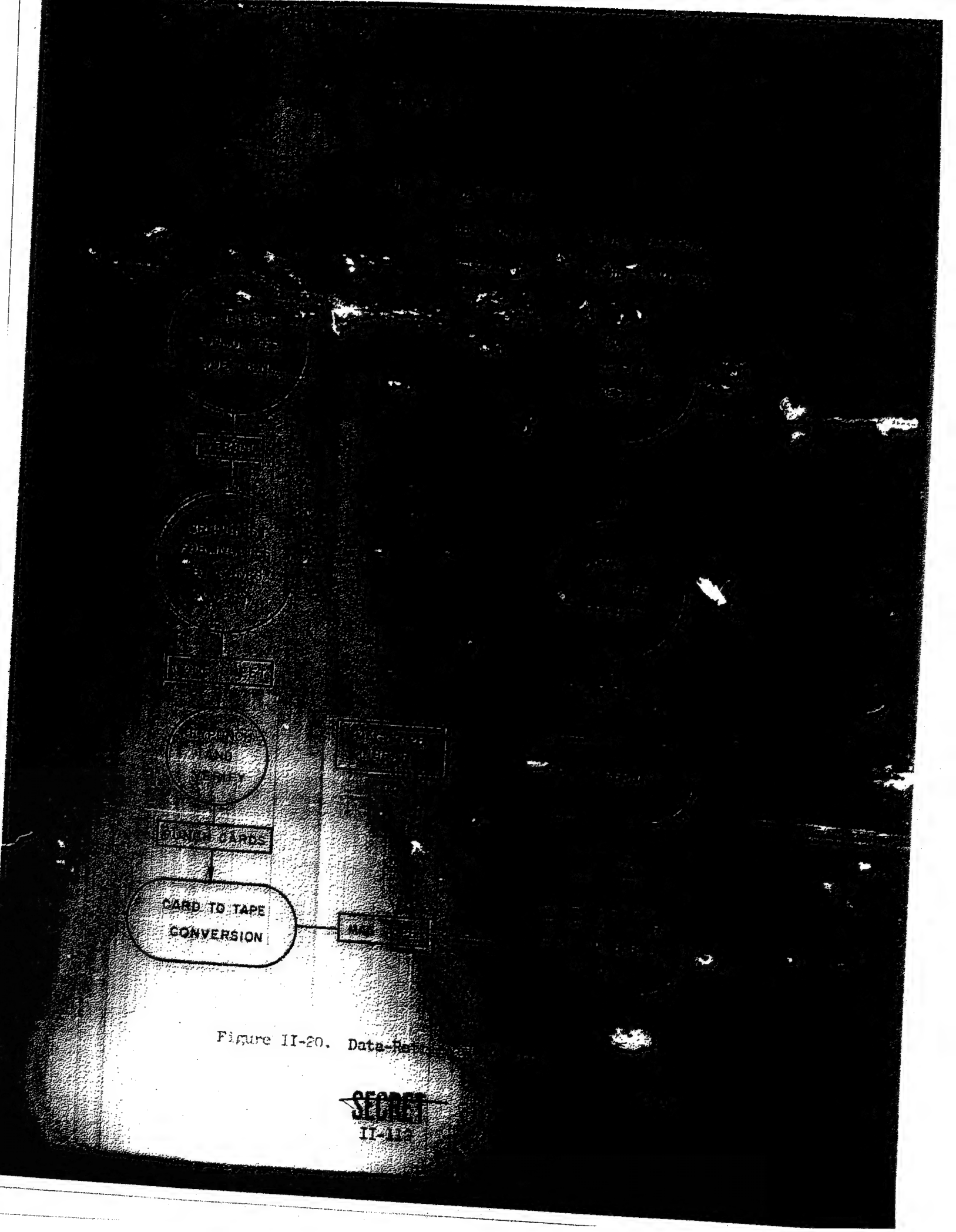


Figure II-20. Data-Re

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] lacets, such as, [illegible] of events or of [illegible] indexing is performed [illegible] some encouraging developments [illegible]

[illegible]amination of the techniques [illegible] activities for indexing, [illegible] the keynote is diversity. [illegible] and maintained locally. The [illegible] only differences in the kinds [illegible]

[illegible]

[illegible]

[illegible]

b. Data Stored

A major long-term trend [illegible] less money." Whereas [illegible] ization of the relative [illegible] to shift in favor of [illegible] reflected in the use of [illegible] puters distributed throughout the system.

[illegible]

[illegible] shown on [illegible]
density and high [illegible]
read-only memory.

A point of some concern is [illegible]
increasing, "mass-memory [illegible]
dary storage devices. [illegible]
access to very large data [illegible]
central processor, in that [illegible]
for access to the secondary [illegible]
predominantly of this type it [illegible]
processor.

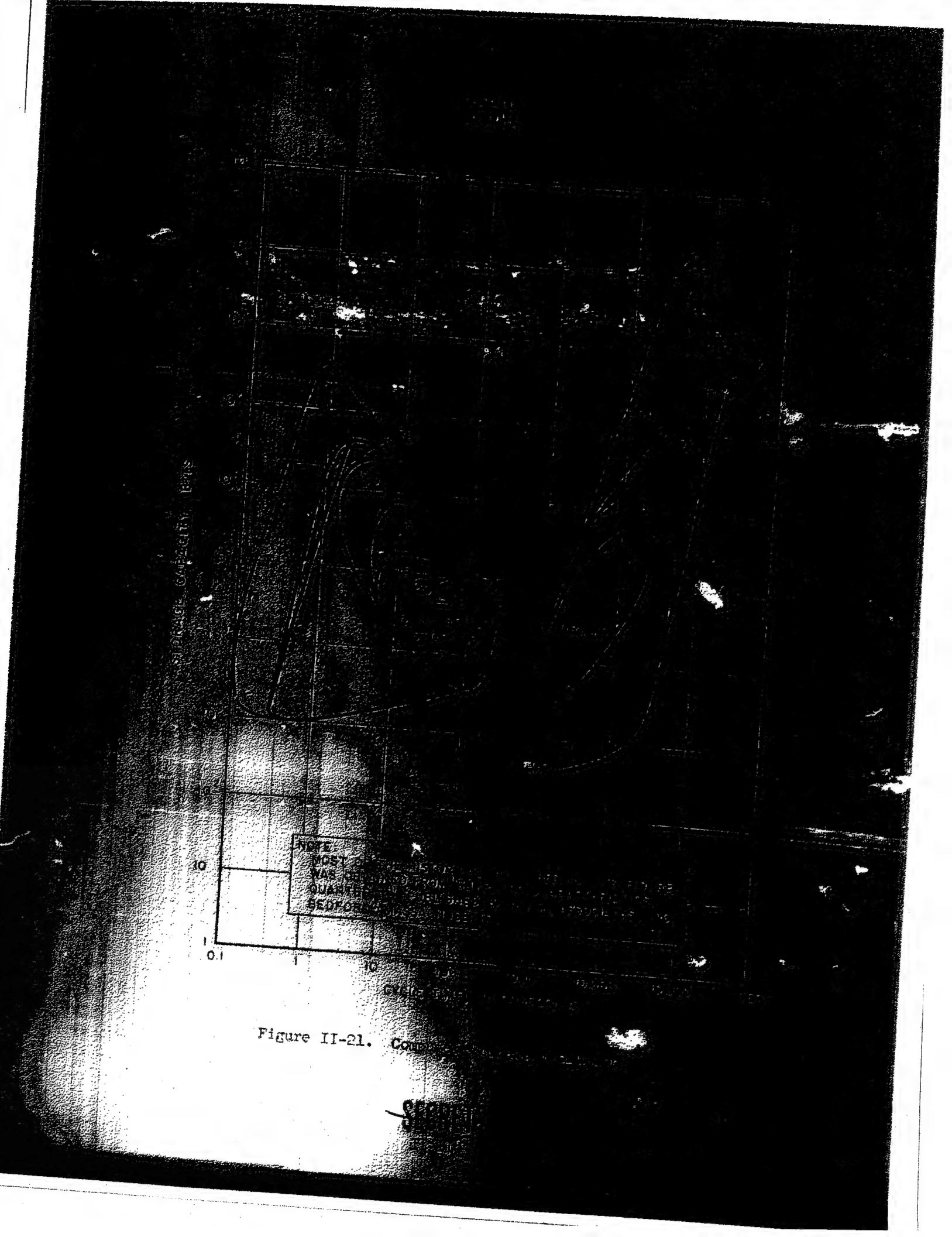


Figure II-21. Com

[illegible]

[illegible] on film and [illegible]
[illegible]ional problems.

Although several associa[illegible]
is not expected that these [illegible]
processing despite the fu[illegible]
Reasons constituting the ba[illegible]

1) Most of the functio[illegible]
can be accomplished [illegible]
memories at comparable [illegible]

Table [illegible] Reported State-of-the-art Data Processing Equipment

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

[illegible] each item [illegible]
magnetic-disc files or [illegible]
more direct access to [illegible]
accomplishment is to use [illegible]
"network structures" to [illegible]
"network structures" with [illegible]
processing techniques to [illegible]
Dynamic allocation of both [illegible]
necessity.

[illegible] Projected State of the Art Data Processing Technologies

Technology	[illegible]	[illegible]	[illegible]
Programming			
Languages			
[illegible]			
[illegible]			
[illegible]			
[illegible]			
[illegible]			

the contents of the
most potential is to tr
and thereafter employ the
questions about the curr
in formulating procedure

The goal of conciseness can
new terms to the machine.
name to some composite colle
avoid having to itemize them.
reports could be defined and th

[illegible]

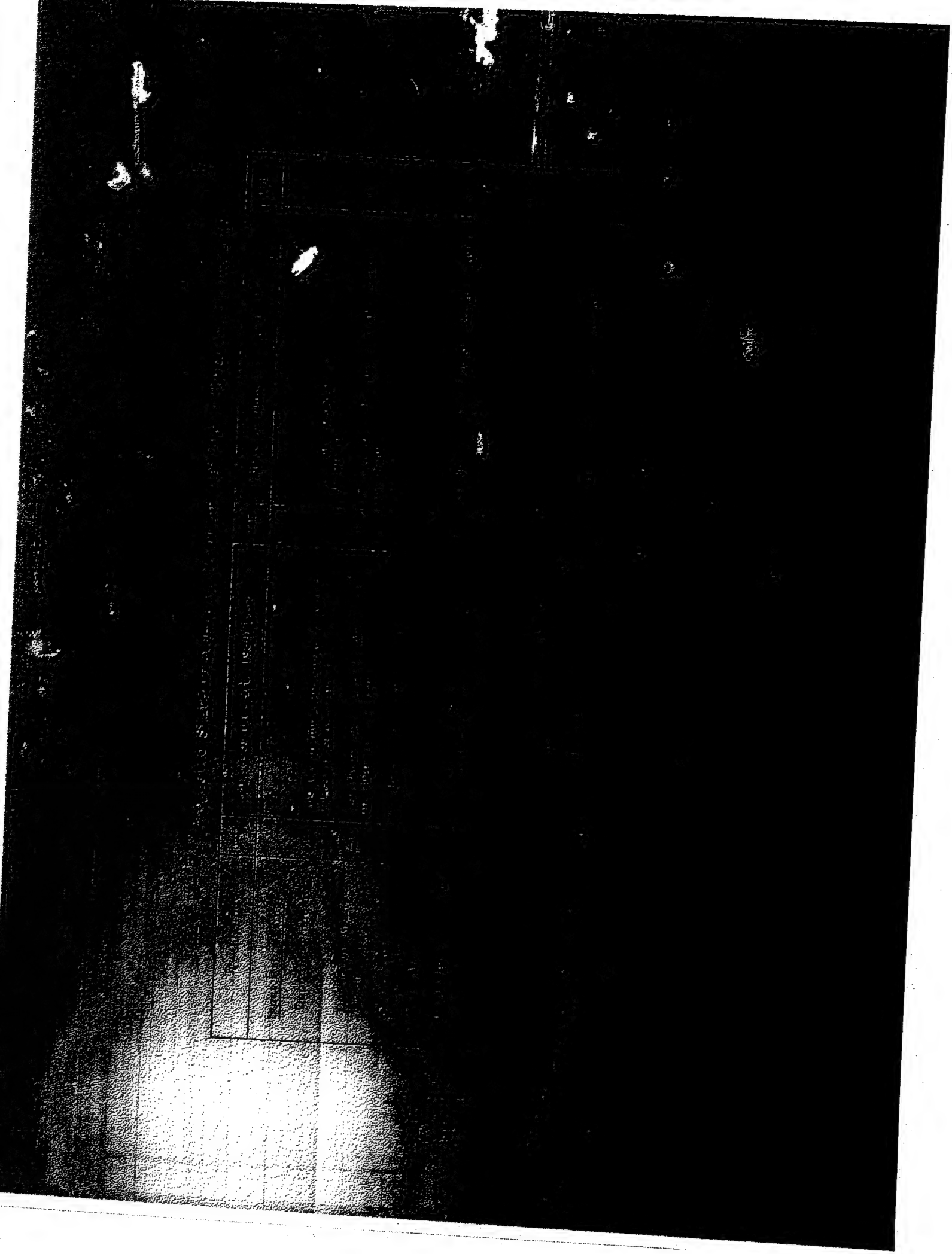
[illegible] Other Storage

[illegible]

[illegible] number of small [illegible]

[illegible] major [illegible] and lower system cost.

The cost of "integral-index" [illegible] "accession-number" equipment [illegible] advantage of integral-index [illegible] search is unimportant [illegible] computer is available. For [illegible] is expected to predominate in [illegible]



Input Processing

A major problem in the input
vestment that is required
ized files generally require
than manual files, mechanis
in the support staff.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

1) [illegible]

2) [illegible]

3) Improved [illegible]

4) Man/machine [illegible] problems

5) [illegible]

6) Self-teaching [illegible]

7) [illegible]

8) Solutions [illegible]

9) Methods of [illegible] organization [illegible] and [illegible]

10) Meta-linguistics [illegible] Section [illegible]

11) Improved [illegible] Section [illegible]

12) Inter-machine [illegible] geographically [illegible]

13) Linguistics in [illegible]

14) Methods for measuring [illegible] dissemination, [illegible]

[illegible]

[illegible]

[illegible]

Techniques for providing [illegible]
are now being explored [illegible]
electro-optical sensors [illegible]
tude, whereas radar ranging [illegible]
bining these data with [illegible]
ELINT and COMINT techniques [illegible]
Gross location of emitter [illegible]

[illegible]

[illegible]

[illegible]

so that the human eye
only. Transmission to
tems except coherent rad
recording, or in near real
ing or filtering has been
will still require at least
raw data and for processing
posite displays for human

[illegible]

[illegible]

[illegible] problem areas [illegible]

[illegible] Multisensor [illegible]

2) Near-real-time [illegible]

3) Reduction of [illegible]

4) Maximum man/machine [illegible]

5) Automation of [illegible]
sensory data for [illegible]

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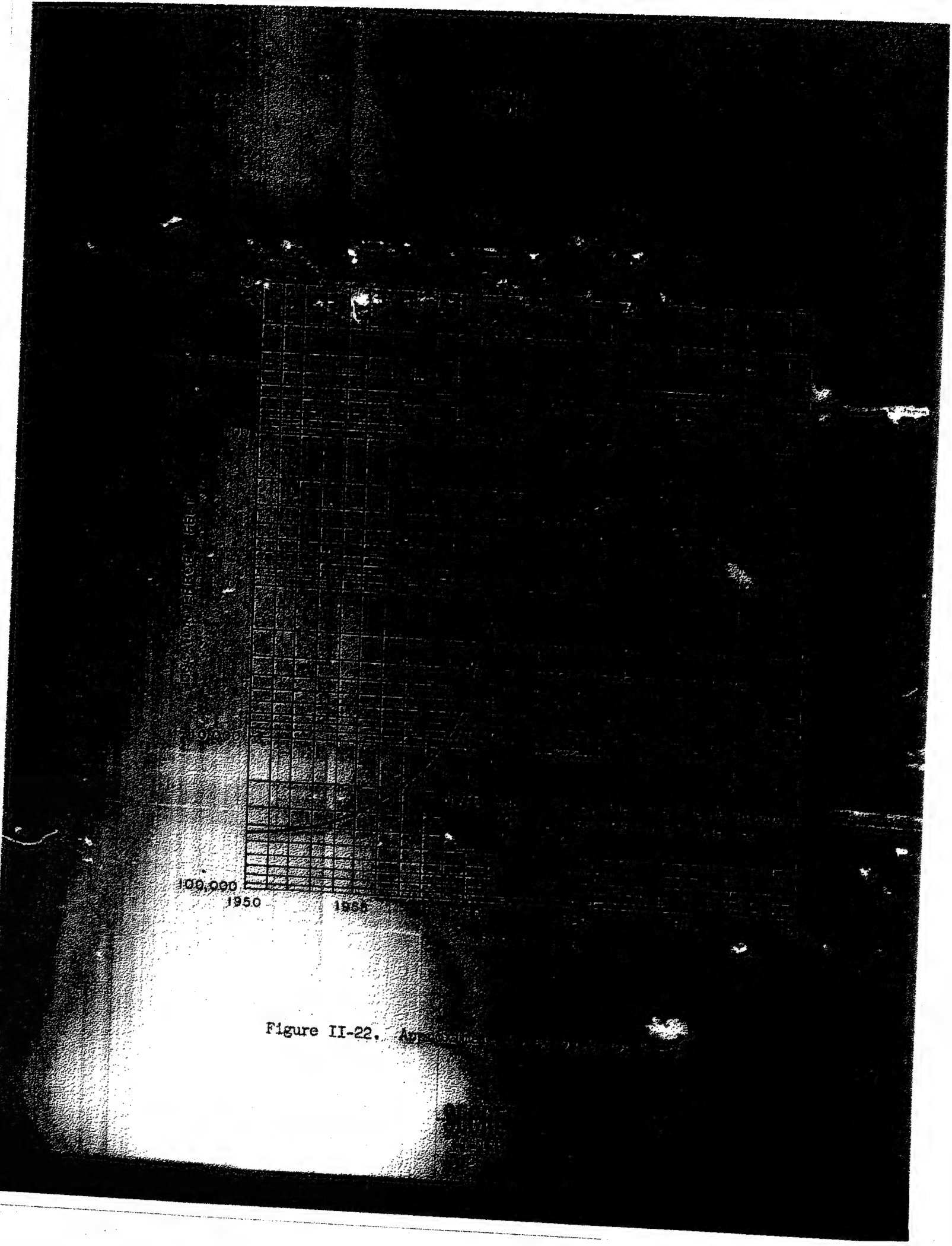

Figure II-22. Appr

[illegible]

[illegible]

[illegible]

12) High-frequency [illegible]

13) Cosmic-noise [illegible]

14) Atmospheric [illegible]

15) Direct optical [illegible]

16) IR/UV radiometry [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Correlation [illegible]

[illegible] correlation is [illegible]
[illegible] detection techniques
[illegible] systems. The [illegible]
[illegible] laboratory type operations [illegible]
controlled photo processing, [illegible]
[illegible] tion, technical intelli[illegible]
cost of this facility will be [illegible]

(U) The Eglin [illegible]
environment [illegible]
swamps, [illegible]
that are [illegible]
Commander on the [illegible]
ities of insurgent [illegible]
Deficiencies for [illegible]
two categories of [illegible]
vehicles, small [illegible]
instrumentation such [illegible]
permit flare drops [illegible]
delta of the Choctawhatchee [illegible]
period of time to [illegible]
Delta in South Viet Nam [illegible]

[illegible]

[illegible] for establishment of the [illegible]
[illegible] will be on the order [illegible]

[illegible] Low-Altitude Photogrammetric [illegible]

In order to avoid early detection [illegible]
aircraft must penetrate enemy [illegible]
reconnaissance and weapon systems [illegible]
buffeting and high-g forces in the [illegible]

APPENDIX A

GLOSSARY

Achromatic light - [illegible] the visible electromagnetic spectrum so that [illegible] metallic luster [illegible]

Angular resolution - The angle subtended at the sensor by the spatial resolution.

Apodization - A technique used to [illegible] the aperture in order to [illegible] fried, usually by [illegible] [illegible] [illegible]

Collection - Activity thereby information is accumulated. For example, documents may be collected or sensors may be used to collect information on a [illegible] target. Information may be collected by observation, [illegible] or [illegible] or from a mobile platform or [illegible].

Counter-guerrilla warfare - Offensive operations conducted by armed forces and/or military agencies of an established government and/or its allies against guerrilla forces.

Counter-insurgency (COIN) - The entire range of military, paramilitary, political, economic, psychological, and civic actions taken by or with the government of a nation to defeat insurgency (guerrilla) activity associated with [illegible].

Cryostat - A device used to lower temperature by passing a gas at high pressure through a small aperture into an area of lesser pressure.

Data base - An all-inclusive body of information upon which serves as a basis against which new information may be compared, or which, through constant refinement, serves as a solid basis of departure for planning.

Decibel milliwatts (dbm) - 1 dbm = 10 log (power out)/(1 milliwatt power in).

Decibel watts (dbw) - 1 dbw = 10 log (power out)/(1 watt power in).

Ephemeris (pl. ephemerides) - A table giving the position of natural or artificial heavenly bodies as a function of time.

Exploitation - Correlation of information from intelligence records (i.e. locations shown in photos, signal analysis, [illegible] number positioning) with other available data for synthesis in the production of an intelligence estimate.

Extraction - From the standpoint of intelligence functions extraction constitutes the first phase or task in obtaining information from a record to be used as a basis for subsequent exploitation and analysis.

FORTRAN - An acronym for "Formula Translation" (IBM common algebraic computer language).

Gelatin - A sheet [illegible] that can be carried by day over a prepared area [illegible] to be lighted.

General war - Armed conflict between the major powers in which the total resources of the combatants are employed and the national survival of a major belligerent is in jeopardy.*

Ground resolution - The size of the smallest object on the ground that can be distinguished on a device record by an interpreter.

Ground truth - Data which describes the true situation on the ground at the time that a compare-some sensor was in collection. This information consists of verification, emission, and description of target and background as well as meteorological data.

Guerrilla warfare (GW) - Combat operations conducted generally in enemy-held territory by irregular, indigenous forces on a military or paramilitary basis to reduce the combat effectiveness, (industrial, economic, political, and military war potential), and morale of the enemy.

Hard copy - A finished copy - directly readable.

Identification - The degree of detail that precedes determination of the general characteristics of an object and the notation that may be performed.

Imbibed emulsions - Photographic materials which include light-sensitive components and most of the required developing chemicals.

Intelligence - The product resulting from collecting, evaluating, analyzing, integrating, and interpreting all available information which concerns one or more aspects of foreign nations or of areas of operations and which is immediately or potentially significant to military planning and operations.

*JCS definition

Insurgency, level of [illegible]

Phase II. This phase [illegible] from Phase I when the subversive [illegible] organized guerrilla warfare or [illegible] forms of violence against the established authority.

Phase III. The situation moves from Phase II to Phase III when the insurgency becomes primarily a war of movement between organized forces of the insurgents and those of the established authority.

Laser* - Light amplification by stimulated emission of radiation.

Limited war* - Armed conflict short of general war, exclusive of incidents involving the overt engagement of the military forces of two or more nations.

Mapping and geodesy - The collection of high-accuracy reconnaissance data for producing accurate maps of actual or potential battle areas and for accurate target location. The geodetic aspect usually implies refinements such as [illegible] of bench marks to establish datum relationships, gravity anomaly measurements, etc.

Meta-language - A language used to describe other languages and the translations between them.

Mission - The broad purpose or basic character of an organization.

Nanobath web - A porous carrier material which stores a chemical solution that will develop and fix a photographic image on contact.

Nanosecond - A measurement of time equal to 10^{-9} seconds.

Neutralization - Action taken against an enemy element rendering it incapable of performing its mission. Neutralization includes killing or destroying.

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*JCS definition

Cadence - The interval between successive [illegible] a basic frequency [illegible] of two.

Photographic reconnaissance - A method of [illegible] by photography [illegible] to [illegible].

Real time - A measurement of time [illegible] or approaches, instantaneous.

Reconnaissance - Includes a combined mission of reconnaissance and [illegible] or are searching enemy [illegible] and [illegible] appropriate targets. A modified version has been performed [illegible] on targets suspected, already hit and [illegible] if necessary.

Reconnaissance - A mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area.

Reconnaissance, area search - Reconnaissance performed for locating and identifying potential targets.

Reconnaissance missions -

Area Search - Reconnaissance performed for detecting and identifying potential targets.

Operational - Reconnaissance performed by [illegible] detail to permit identifying objects previously detected in areas of interest.

Objective - Reconnaissance performed to provide the detail necessary to permit analysis of specific objects, including their technical aspects.

Reconnaissance system - All aspects of the reconnaissance from data acquisition or collection through data processing, condensation and extraction.

Reconnaissance, tactical air - The collection by aerial vehicles of information on terrain, weather, electronic and communication emissions and on air, sea, and ground forces or installations, lines of communications, and [illegible] as required to plan and conduct tactical military operations.

*JCS definition

SECRET

Reconnaissance, weather - [illegible]

Signature analysis - [illegible]

Special warfare - Special warfare encompasses [illegible] psychological warfare. [illegible] Insurgency is primarily associated with [illegible] limited war or general war [illegible] as a major [illegible] throughout the entire spectrum of [illegible] and general war.

Squint angle - The angle between the two major lobe axes of a lobe-frequency radar or [illegible].

Squint mode - The angular difference between the axis of an antenna radiation and a selected geometric axis, such as the axis of the reflector.

Strategic warning - A notification that enemy-initiated hostilities may be imminent. The time element may vary from minutes to hours, days, or more.

System - A composite of personnel, equipment, facilities, and techniques intended to perform and/or support an operational role. A complete system includes vehicles and [illegible] related facilities, sensors, equipment, materiel, services, and the personnel required for its operation to the degree that it can be considered a self-sufficient unit in the intended operational and/or support environment.

Tactical warning - Notification that the enemy has initiated hostilities. Such warning may be received any time from the launching of the attack until it reaches its target.

Target Description — A single [illegible] of the reconnaissance data [illegible] and [illegible] Reconnaissance.

Tasking — [illegible] based upon [illegible] mission [illegible]

Tasks — From a [illegible] assignments [illegible] or a major element within the [illegible] by-step procedures [illegible]

Technical Intelligence — The [illegible] and products resulting from research [illegible] of information collected by appropriate means [illegible] the progress on or the [illegible] in all technical [illegible] other being pursued by a country.

Unconventional Warfare — Includes the three interrelated fields of guerrilla warfare, evasion, escape, and subversion against hostile states. Unconventional warfare operations are conducted within enemy or enemy-controlled territory by guerrilla/irregular military personnel normally supported and directed to varying degrees by an external source and are primarily associated with limited war or general war conditions.

Up-converter — The type of parametric amplifier which is characterized by the frequency of the output signal being greater than the frequency of the input signal.